RESTRICTED

The
NORDEN BOMB SIGHT

- MAINTENANCE
- CALIBRATION

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B. S. M. DIVISION
DEPARTMENT OF ARMAMENT
LOWRY FIELD, COLORADO

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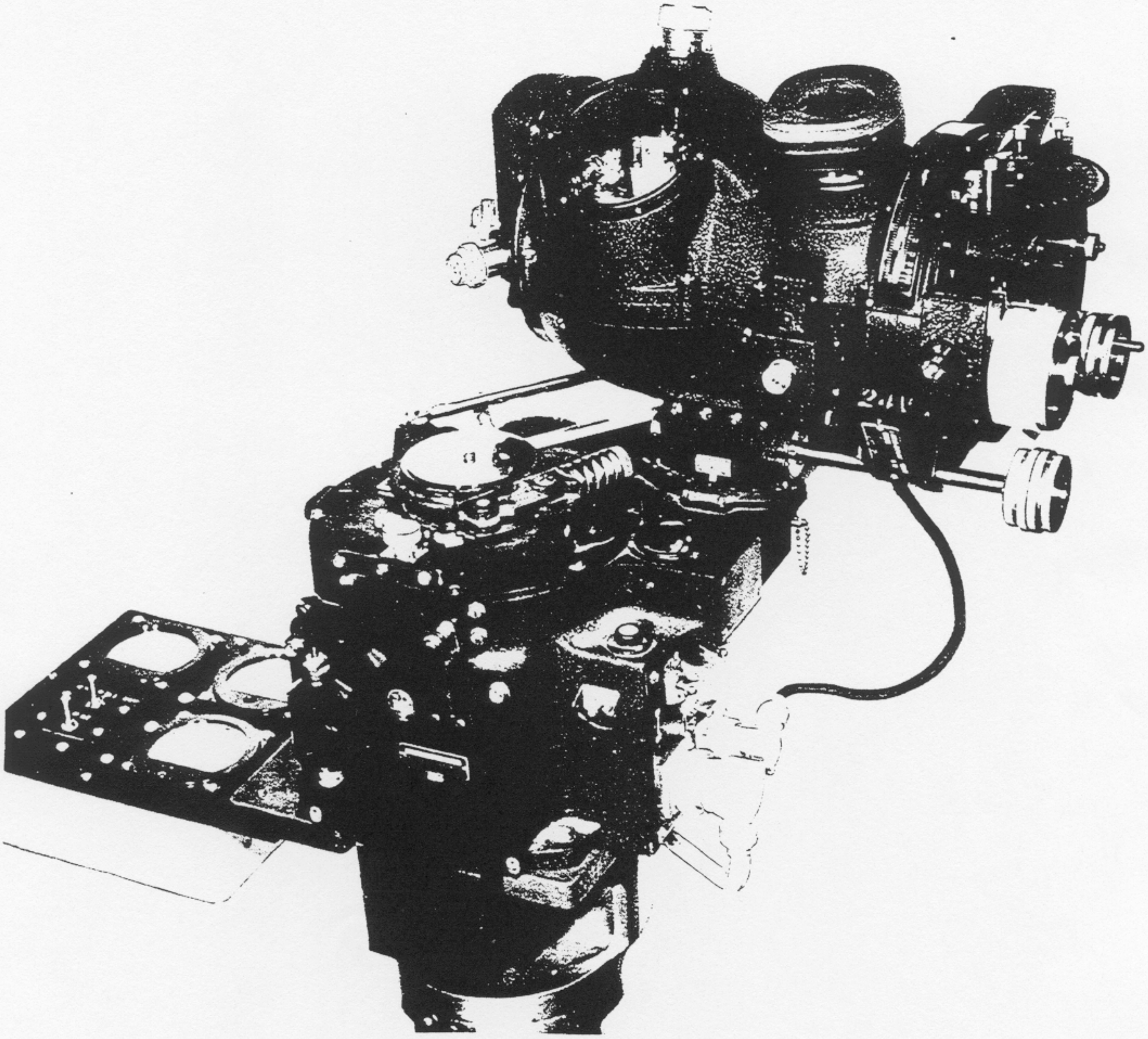
BOMB SIGHT "M"-SERIES



FOREWORD

The purpose of this manual is to provide a source of information from which the student may acquire the knowledge needed to perform first and second echelon maintenance on the Norden Bombsight Equipment, M-Series.

Memorization of the material in this manual will not produce well trained maintenance men. It is the job of the Instructor to provide the practical application of the text material.

The student must be constantly reminded that his mastery of the text material is essential and that he must train himself so that he can apply what he has learned.

A well trained maintenance man must have the following prerequisites:

1. Thorough knowledge of the equipment.
2. Pride in his workmanship.
3. Common sense.
4. Ability to use his hands.

If the maintenance man has the above prerequisites, he may develop an ability to maintain perfectly the equipment.

This manual is divided into sections. This arrangement provided a method whereby all the material concerning the stabilizer is presented in Sections I and IV, inclusive, and the material concerning the sight is presented in SectionsV to X, inclusive.

Such an arrangement of the text material also provides for any future changes.

The illustrations are to aid the student in visualizing exact construction and operation of the equipment and to provide a more interesting presentation of otherwise dry mechanical facts.

This manual was set up with the idea in mind that a definite amount of time be spent in the study of the manual and a discussion of the material studied.

The instructor will co-ordinate the text with the equipment and arrange the work to fit his particular class. Any points which might offer difficulty should be demonstrated and clarified by the Instructor. Disassembly and reassembly and maintenance procedure should be demonstrated and followed through to see that the students are doing the work correctly. This same procedure should also be used in calibration.

It should be stressed that the equipment is precision made and that proper handling and lubrication are very essential. Instructions given in the manual for handling and lubrication should be strictly followed, unless local conditions warrant a change of instructions concerning lubrication.

A good maintenance man will not tinker with the equipment. As long as the equipment functions properly, there is no need to disassemble or to tinker. However, keep the unit clean, dry and properly lubricated. **PREFLIGHT CHECKS AND INSPECTIONS WILL BE MADE WHEN DUE, AND ANY MALFUNCTIONS CORRECTED. KNOW WHAT TO DO; KNOW HOW TO DO IT; KNOW WHEN TO DO IT, AND THEN DO IT.**

Good maintenance men will always be in demand. Thorough training will provide the confidence necessary for good maintenance.

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INTRODUCTION

Precision bombing, as developed and demonstrated by the United States, has proved to be practical and successful. As a result of the success of precision high level bombing the bombardment squadron has become one of the most important groups of the Army Air Forces.

A bombardment squadron may have everything but an accurate bombsight and still be unable to accomplish its purpose. The purpose of any bombardment squadron is to provide a means of transporting the bombs to a point from which, when the bombs are released, they will strike the target. The bombsight determines that point of release. If the bombsight is not accurately calibrated and maintained, the bombs will not strike the target and consequently the bombing mission is a failure.

It is the duty and responsibility of the bombsight maintenance personnel to have their equipment in perfect operating condition. If they fail to perform their duty, they are endangering the success of the bombing mission, the lives of the crew, the plane and all equipment for which they are responsible.

As bombsight maintenance personnel, your job is one of the most important jobs in a bombardment squadron. If the bombardment squadron has the best planes, pilots, bombardiers, navigators, gunners, and ground crews in the service the bombing missions may be a failure because the bombsights were inaccurately calibrated. The sight determines the point of bomb release and also determines the correct course. The pilot will fly the course determined and the bombsight will release the bombs at the determined dropping angle. If either the course or range is incorrect, the bombs will miss the objective. Therefore, no matter how accurately the plane is kept on course the objective of the mission will not be accomplished.

Upon the shoulders of the bombsight maintenance personnel rests the responsibility of accurate calibration and maintenance and to that extent the success or failure of a bombing mission.

You cannot and must not make any attempt to shift that responsibility. You are a soldier of the United States Army Air Forces. Uphold the tradition and heritage of your Country, your branch of the Service and Victory will be ours.

STABILIZER
REAR VIEW

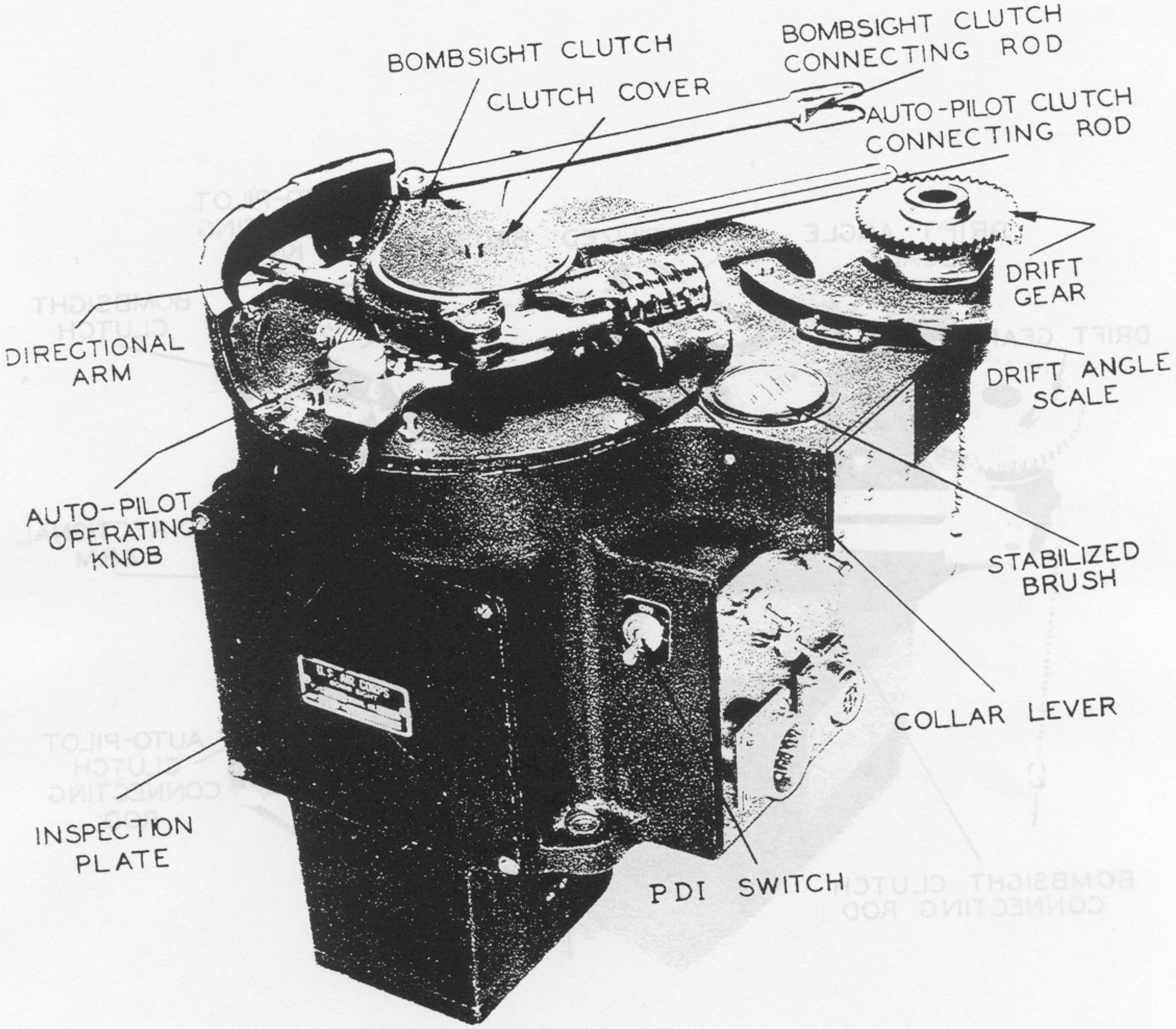


FIG. 1

STABILIZER FRONT VIEW

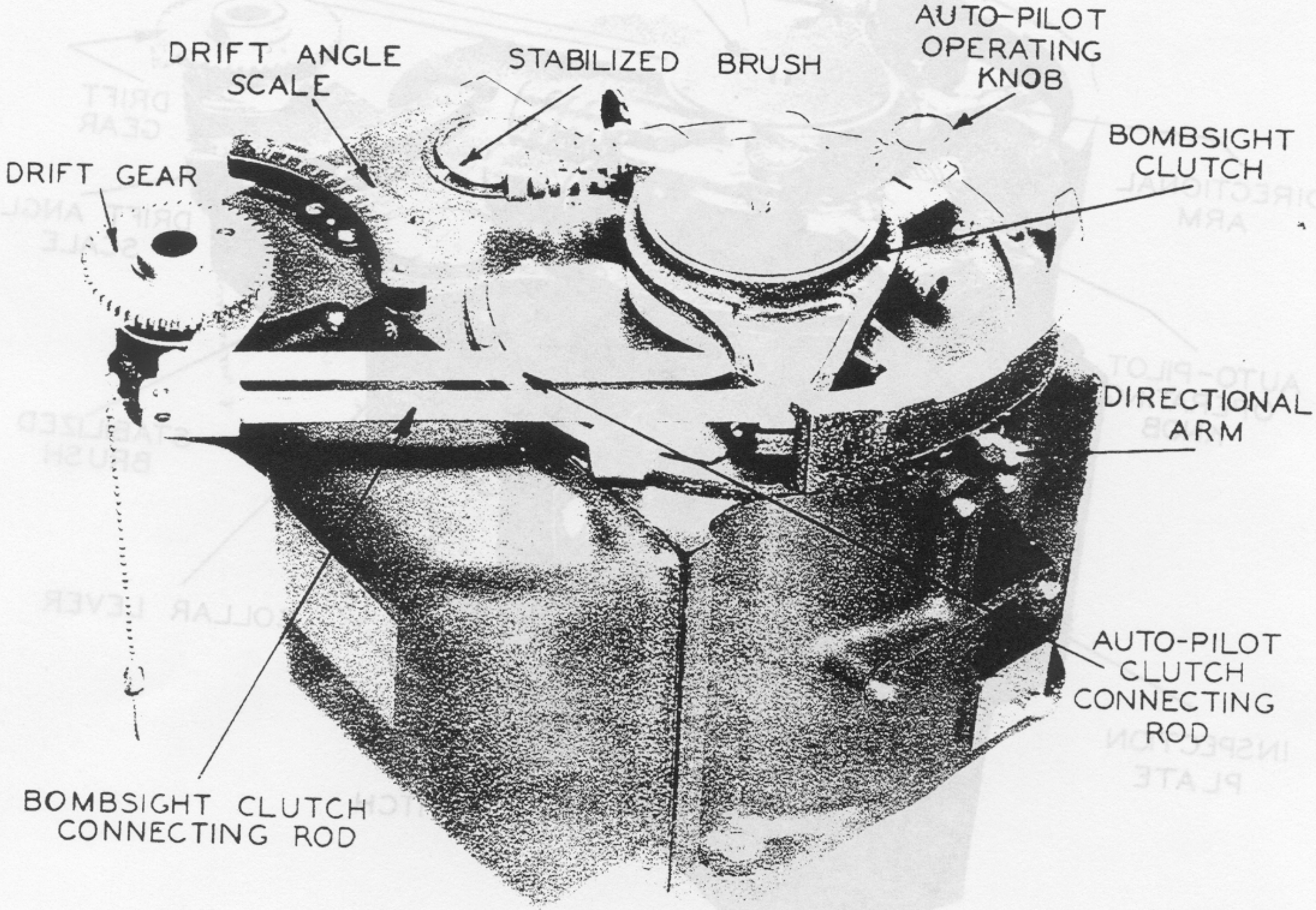

DRIFT ANGLE SCALE
STABILIZED BRUSH
AUTO-PILOT OPERATING KNOB
BOMBSIGHT CLUTCH
DRIFT GEAR
DIRECTIONAL ARM
AUTO-PILOT CLUTCH CONNECTING ROD
BOMBSIGHT CLUTCH CONNECTING ROD

FIG. 2

SECTION I

OPERATION AND NOMENCLATURE STABILIZER

PURPOSE OF STABILIZER

The stabilizer is used as a base for the bombsight and provides the housing and mountings for the mechanical devices used to maintain an azimuth reference line, or more specifically, to stabilize the bombsight case (i.e. entire case including the fore and aft hair) in azimuth, and with AFCES in operation to stabilize the entire plane against deviations from course.

GENERAL DESCRIPTION OF STABILIZER

FIG. 1-2

In our discussion of the stabilizer, we will use the terms front and rear, right and left, as the stabilizer is seen from the position of the bombardier. On the rear of the stabilizer housing is an inspection plate or cover which is fastened to the housing with four screws. The removal of this cover permits inspection of the horizontal gyro and cardan.

To the right of the rear cover is the PDI switch. On the top of the stabilizer are the following: clutch cover plate, bombsight clutch, bombsight clutch connecting rod, bombsight clutch connecting rod clamp bracket, auto-pilot clutch, directional arm, PDI coil and brush view glass, drift gear and clutch assembly, and drift scale.

The PDI coil mounting plate, the switch panel containing, as designated, the stabilizer, servo and bombsight switches, the stabilizer and the bombsight male cannon plugs are on the right side of the stabilizer housing.

Located on the front of the stabilizer housing is the torque or servo motor, which is accessible by removing the inspection cover which is attached with four screws.

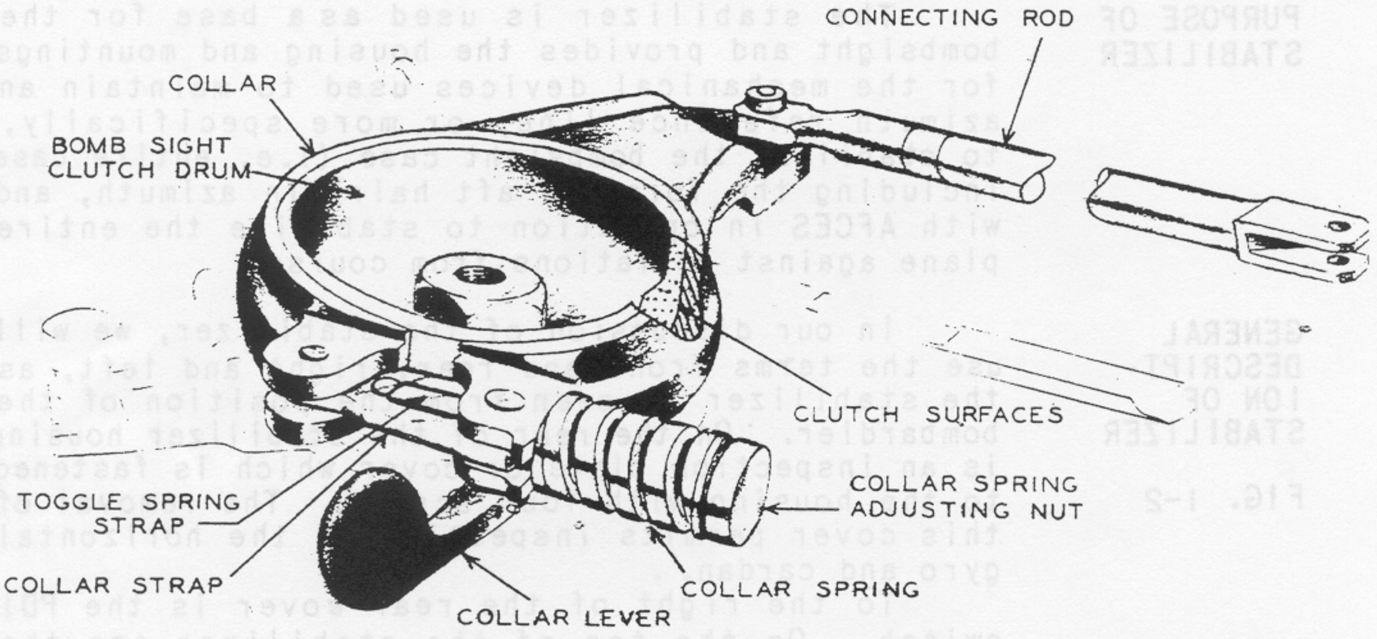
On the left side of the housing are the projections for mounting the directional panel.

STABILIZER ASSEMBLIES

A. Bombsight Clutch (Directional)
C. L. I.
B-43-12

The bombsight clutch is purely mechanical. It provides a slip connection between the horizontal gyro and the bombsight. The clutch is engaged and disengaged by operating the bombsight clutch thumb lever. The male part is the upper end of the directional stabilizer cardan gudgeon. A spring and nut are provided for adjustment of the clutch tension. The clutch must be adjusted to

BOMB SIGHT CLUTCH ASSEMBLY



AUTO-PILOT CLUTCH ASSEMBLY

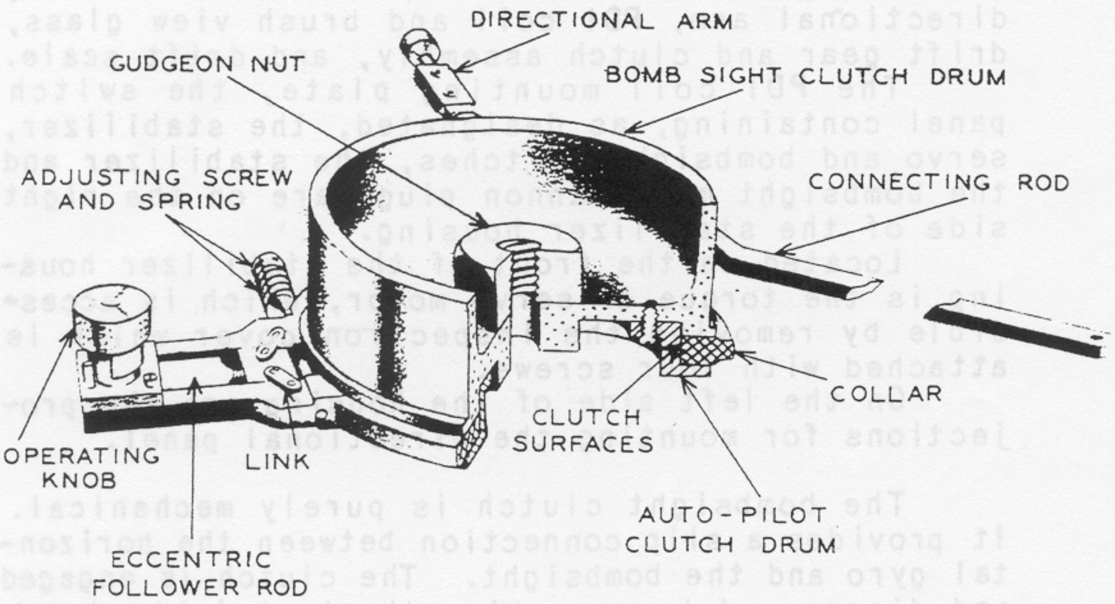


FIG. 3

P.D.I. AND DRIFT CLUTCH ASSEMBLIES

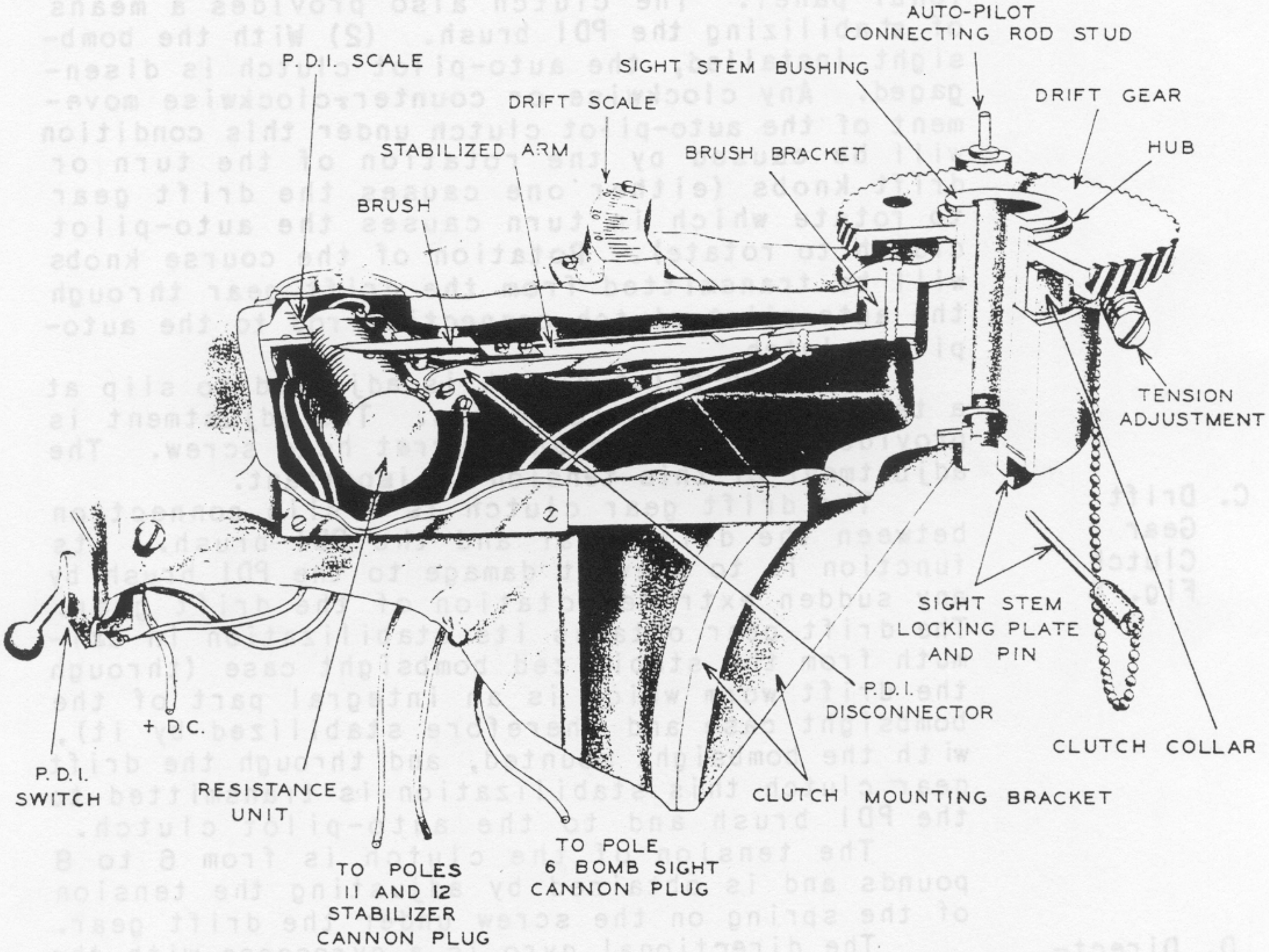


FIG. 4

Fig. 3

a tension of 18 to 24 pounds, so that the clutch will slip before any damage is done to any of the connected units.

B. Auto-Pilot Clutch

Fig. 3

The auto-pilot clutch is also a mechanical arrangement affording a slip connection between the horizontal gyro and the PDI brush. The auto-pilot clutch has a two fold function. (1) Without the bombsight installed, the auto-pilot clutch provides a means of transmitting directional impulses from the directional gyro to the directional panel. The clutch also provides a means of stabilizing the PDI brush. (2) With the bombsight installed, the auto-pilot clutch is disengaged. Any clockwise or counter-clockwise movement of the auto-pilot clutch under this condition will be caused by the rotation of the turn or drift knobs (either one causes the drift gear to rotate which in turn causes the auto-pilot clutch to rotate). Rotation of the course knobs will be transmitted from the drift gear through the auto-pilot clutch connecting rod to the auto-pilot clutch.

The auto-pilot clutch is adjusted to slip at a tension of 10 to 12 pounds. The adjustment is provided by a spring and turret head screw. The adjustment of this tension is important.

C. Drift Gear Clutch

Fig. 4

The drift gear clutch is a slip connection between the drift gear and the PDI brush. Its function is to prevent damage to the PDI brush by any sudden extreme rotation of the drift gear. The drift gear obtains its stabilization in azimuth from the stabilized bombsight case (through the drift worm which is an integral part of the bombsight case and therefore stabilized by it), with the bombsight mounted, and through the drift gear clutch this stabilization is transmitted to the PDI brush and to the auto-pilot clutch.

The tension of the clutch is from 6 to 8 pounds and is obtained by adjusting the tension of the spring on the screw under the drift gear.

D. Directional Gyro and Cardan

The directional gyro is a gyroscope with the spin axis mounted in a horizontal plane and pivoted to the cardan at the center of mass of the gyro.

Fig. 5
Fig. 18
pg. 33

The purpose of the gyro is to provide and maintain an azimuth reference line.

The directional gyro rotates about an approximately horizontal axis. It is carried by horizontal gudgeons working in bearings in a cardan, which cardan itself rotates in vertical gudgeons working in bearings in the stabilizer housing.

STABILIZER GYRO

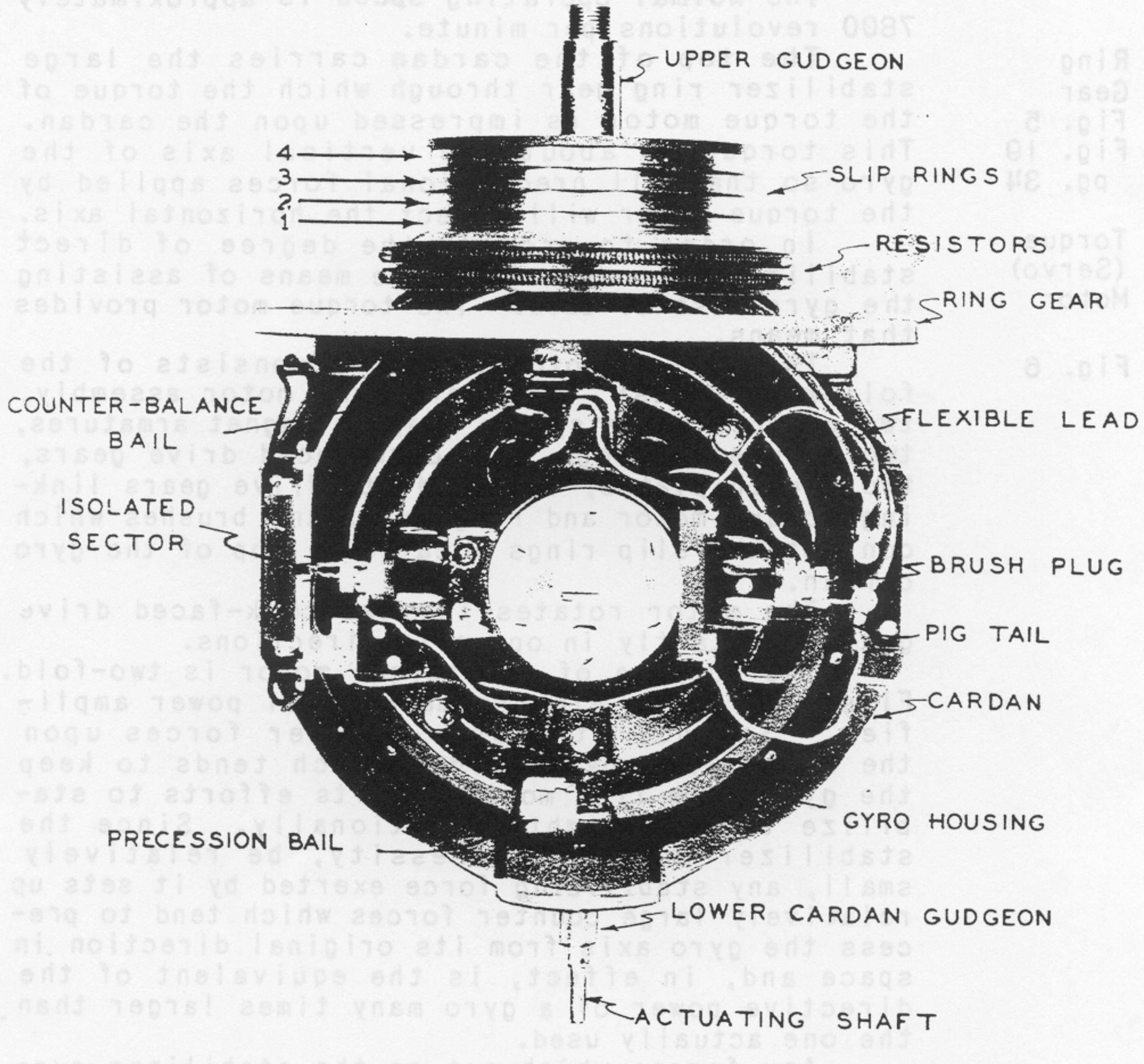


FIG. 5

The upper gudgeon of the stabilizer cardan projects through the top of the case and acts as the male member of the bombsight clutch.

The gyro has a series wound motor. The starting amperage is 6 amps for 24 volt units and 10 amps for 12 volt units. The running amperage is about half of the above amperes as given for 12 and 24 volt units. The M-6 running amperage is 3 to 4 amps.

The normal operating speed is approximately 7800 revolutions per minute.

E. Ring Gear
Fig. 5
Fig. 19
pg. 34

The top of the cardan carries the large stabilizer ring gear through which the torque of the torque motor is impressed upon the cardan. This torque is about the vertical axis of the gyro so that all precessional forces applied by the torque motor will affect the horizontal axis.

F. Torque (Servo) Motor

In order to provide the degree of direct stabilization necessary, some means of assisting the gyro must be used. The torque motor provides that means.

Fig. 6

The torque motor assembly consists of the following parts: DC Shunt wound motor assembly, two clapper magnets, two clapper magnet armatures, two bayonet springs, two cork faced drive gears, two clutch plates, intermediate drive gears linking torque motor and ring gear, and brushes which contact the slip rings located on top of the gyro cardan.

The motor rotates the two cork-faced drive gears constantly in opposite directions.

The purpose of the torque motor is two-fold. First, it is an electro-mechanical power amplifier. Second, it exerts counter forces upon the stabilizer gyro cardan which tends to keep the gyro axis from moving in its efforts to stabilize the bombsight directionally. Since the stabilizer must, of necessity, be relatively small, any stabilizing force exerted by it sets up relatively large counter forces which tend to precess the gyro axis from its original direction in space and, in effect, is the equivalent of the directive power of a gyro many times larger than the one actually used.

Any forces which act on the stabilizer gyro in its normal operation do so in such a way as to move the axis in a vertical plane. In such move-

TORQUE (SERVO) MOTOR ASSEMBLY

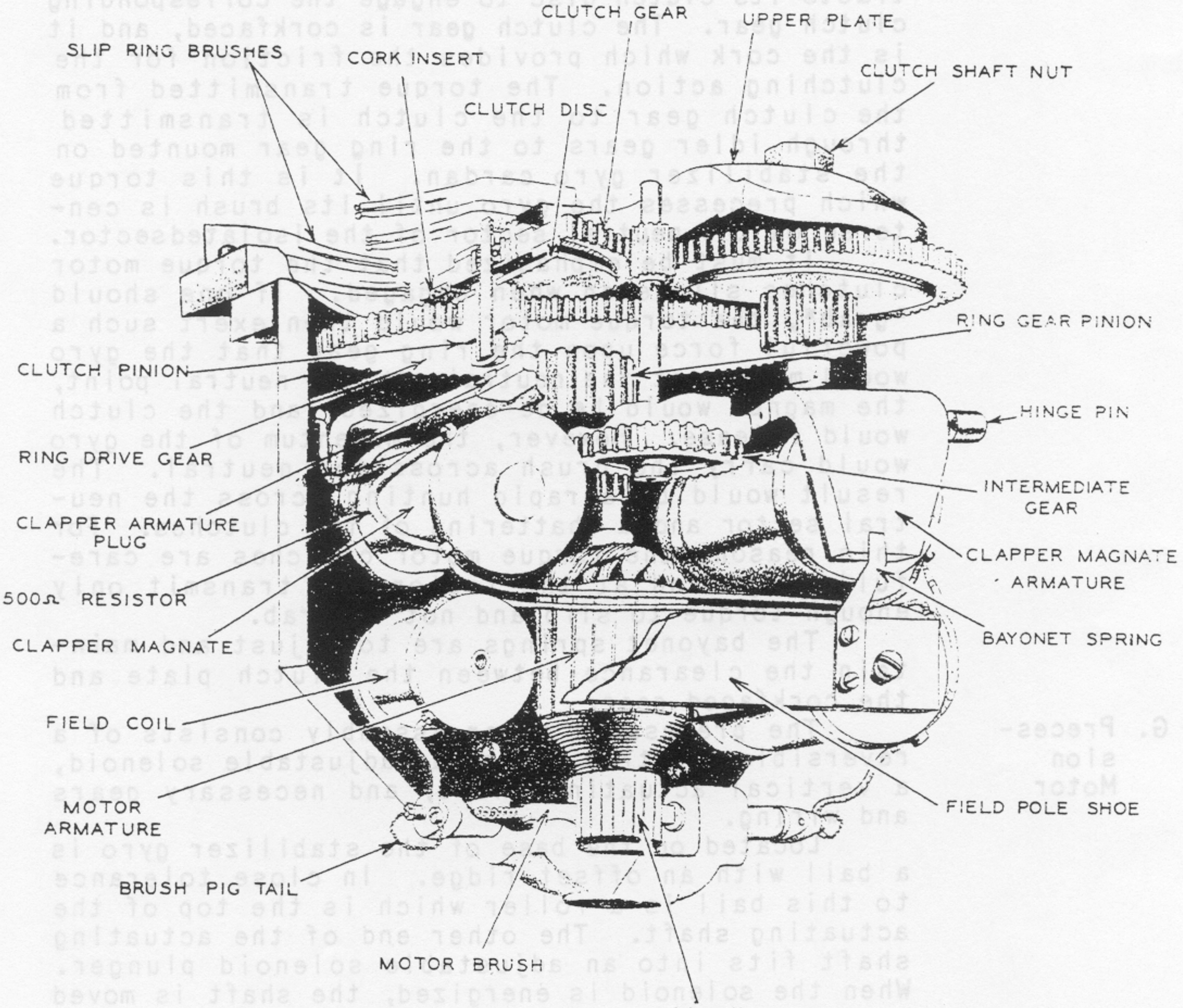


FIG. 6

ment, the stabilizer gyro brush moves off the neutral sector of the torque motor contact sector (isolated sector). That movement closes the torque motor circuits and causes one of the two magnets to be energized. The energized magnet attracts its clutch disc to engage the corresponding clutch gear. The clutch gear is corkfaced, and it is the cork which provides the friction for the clutching action. The torque transmitted from the clutch gear to the clutch is transmitted through idler gears to the ring gear mounted on the stabilizer gyro cardan. It is this torque which precesses the gyro until its brush is centered on the neutral sector of the isolatedsector.

It must be emphasized that the torque motor clutches slip even when engaged. If one should "grab", the torque motor would then exert such a powerful force upon the ring gear that the gyro would move past the neutral. At the neutral point, the magnet would be de-energized, and the clutch would release. However, the momentum of the gyro would carry the brush across the neutral. The result would be a rapid hunting across the neutral sector and a chattering of the clutches. For this reason, the torque motor clutches are carefully adjusted at the factory to transmit only enough torque to slip and not to grab.

The bayonet springs are to adjust and maintain the clearance between the clutch plate and the corkfaced gear.

G. Precession Motor

The precession motor assembly consists of a reversible electric motor, an adjustable solenoid, a vertical actuating shaft, and necessary gears and wiring.

Located on the base of the stabilizer gyro is a bail with an offset ridge. In close tolerance to this bail is a roller which is the top of the actuating shaft. The other end of the actuating shaft fits into an adjustable solenoid plunger. When the solenoid is energized, the shaft is moved upward and the roller comes in contact with the ridge of the gyro bail. Through the precession motor and its intermediate gearing, movement is transmitted to the actuating shaft which causes the shaft to rotate. The shaft may rotate either in a clockwise or counter-clockwise direction, depending upon which way the motor is rotating. When the shaft rotates and the roller presses against the ridge of the ball, a precessional force is applied to the gyro. The direction of the force depends upon the direction the roller is rotating. The precessional force will cause the gyro and cardan to rotate in azimuth. This would force the auto-pilot clutch against the stop until slippage occurred. Any movement of the auto-pilot clutch when flying on AFCE causes the plane to turn. NOTE: Precession motor no longer used.

H. PDI System

Fig. 7

The Pilot Direction Indicator is a double acting voltmeter. With the switch turned "on", when the circuit is equalized, or when the stabilized brush is centered, the pointer (of the pilot indicator) stands in the middle of the scale. When the stabilized brush is off center, the circuit now being unbalanced, the pointer of the PDI moves to one side to indicate the direction which the airplane must turn.

The PDI system in the stabilizer consists of a resistance coil and a stabilized brush. It is connected to an indicator in the pilot's compartment in such a manner as to indicate the approximate amount of turn, and the direction of the turn necessary, at any time when the circuit is energized. The brush is stabilized by the directional gyro through either the auto-pilot clutch or by the bombsight clutch, when the bombsight is installed.

I. PDI Wiring

As previously stated the pilot's direction indicator is an instrument operating as a double acting voltmeter. The action taking place in the stabilizer is as follows: The current passes from the PDI switch to the coil, through the coil, and back to number one pole. The signal from the coil is picked up by the brush and passes through poles five and six (see stabilizer wiring diagram) to the PDI instrument in the pilot's cockpit.

The brush is stabilized by the directional gyro. When the plane turns left the coil moves right under the brush and the signal or reading on the PDI indicates that a right turn is required to bring the plane back to straight flight, or to center the PDI brush. If the plane turns right the coil moves to the left under the stabilized brush and the PDI indicates that a left turn is required to center the PDI brush.

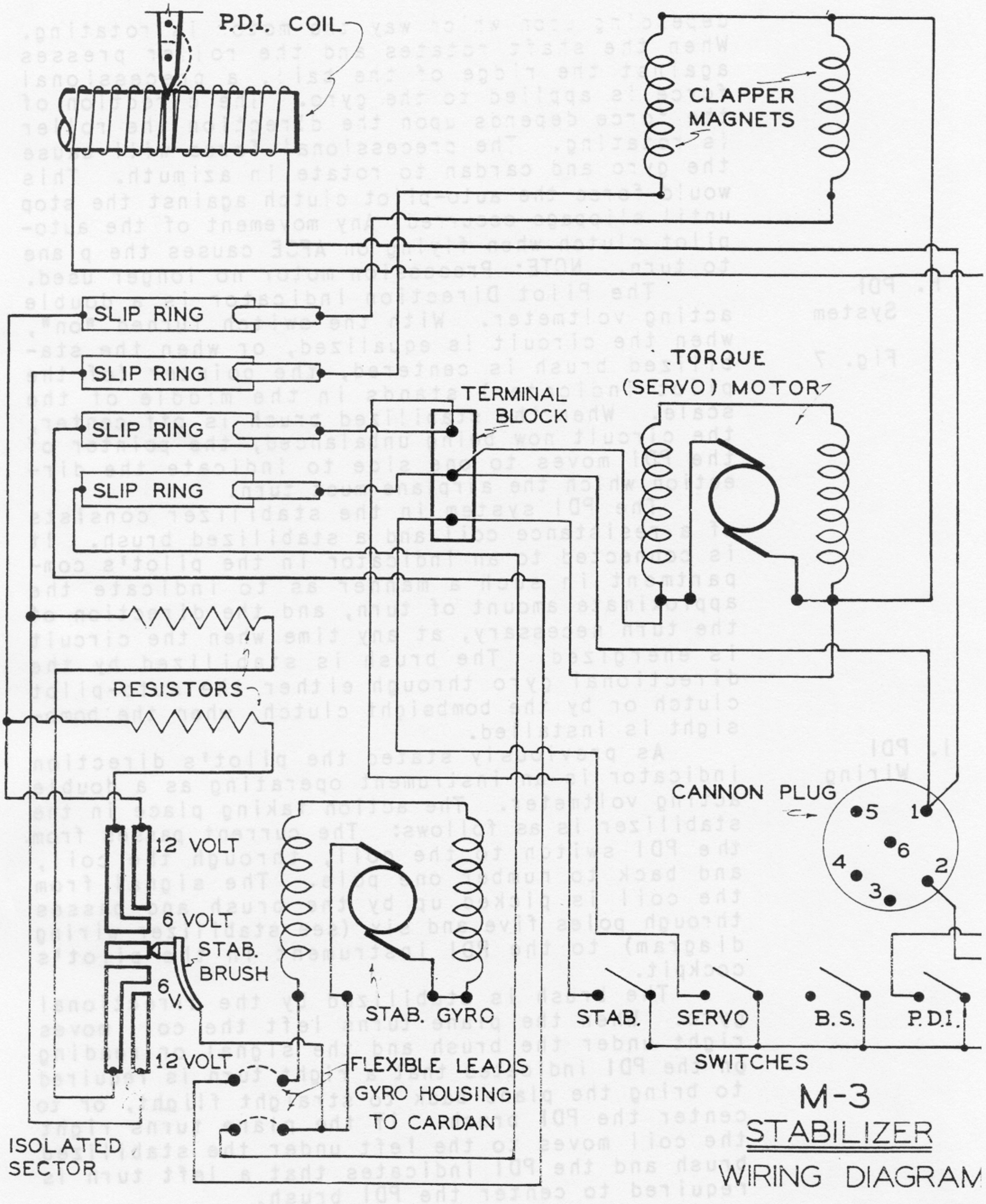

P.D.I. COIL
CLAPPER MAGNETS
SLIP RING
SLIP RING
SLIP RING
SLIP RING
TERMINAL BLOCK
TORQUE (SERVO) MOTOR
RESISTORS
CANNON PLUG
5
1
6
4
2
3
12 VOLT
6 VOLT
STAB. BRUSH
6 V.
STAB. GYRO
STAB.
SERVO
B.S.
P.D.I.
SWITCHES
12 VOLT
FLEXIBLE LEADS GYRO HOUSING TO CARDAN
ISOLATED SECTOR
M-3
STABILIZER
WIRING DIAGRAM

FIG. 7

J. Explanation Stabilizer Wiring Diagram M-3 Fig. 7

The M-3 has a two wire electrical system, a power wire and a return wire.

The current for the operation of the stabilizer comes through the number two pole of the cannon plug from the source of power. The power goes from number two pole to the stabilizer, torque motor, bombsight and PDI switches.

The number one plug is the return connection.

(1) Stabilizer Circuit

When the stabilizer switch is closed, the current flows through the brush contacting the second slip ring from the bottom, or slip ring 2 (see diagram), from the slip ring to the gyro, across a flexible lead, back to the lower slip ring, and then to number one pole, thereby completing the circuit.

(2) Torque Motor Circuit

Close the torque (servo) switch. The current flows to the torque motor, through the motor to the return connection. The current going to the motor branches to the clapper magnets. From the clapper magnets the current goes to the two upper slip rings, 4 and 3, (see Fig. 7). The current from the left clapper magnet (magnet under the brass gear) flows to the third slip ring, then to the lower segments of the isolated sector, through the contact made by the stabilizer brush, across a flexible lead to the lower slip ring, and then to number one pole, or the return.

When the right clapper magnet is energized, the current flows through the fourth slip ring to the upper segments of the isolated sector, through the contact made by the stabilizer brush, across a flexible lead to the lower slip ring, and then to number one pole of the stabilizer cannon plug.

(3) Isolated Sector

The isolated sector consists of five segments which are separated by an insulating material. The five segments are the neutral segment, the upper six-volt segment, upper twelve-volt segment, lower six-volt segment, and lower twelve-volt segment.

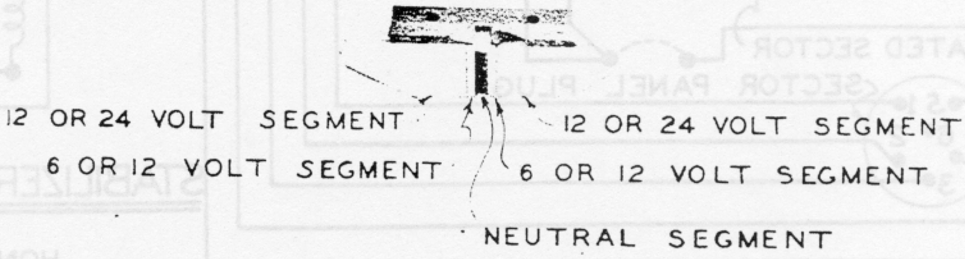


FIG. 8

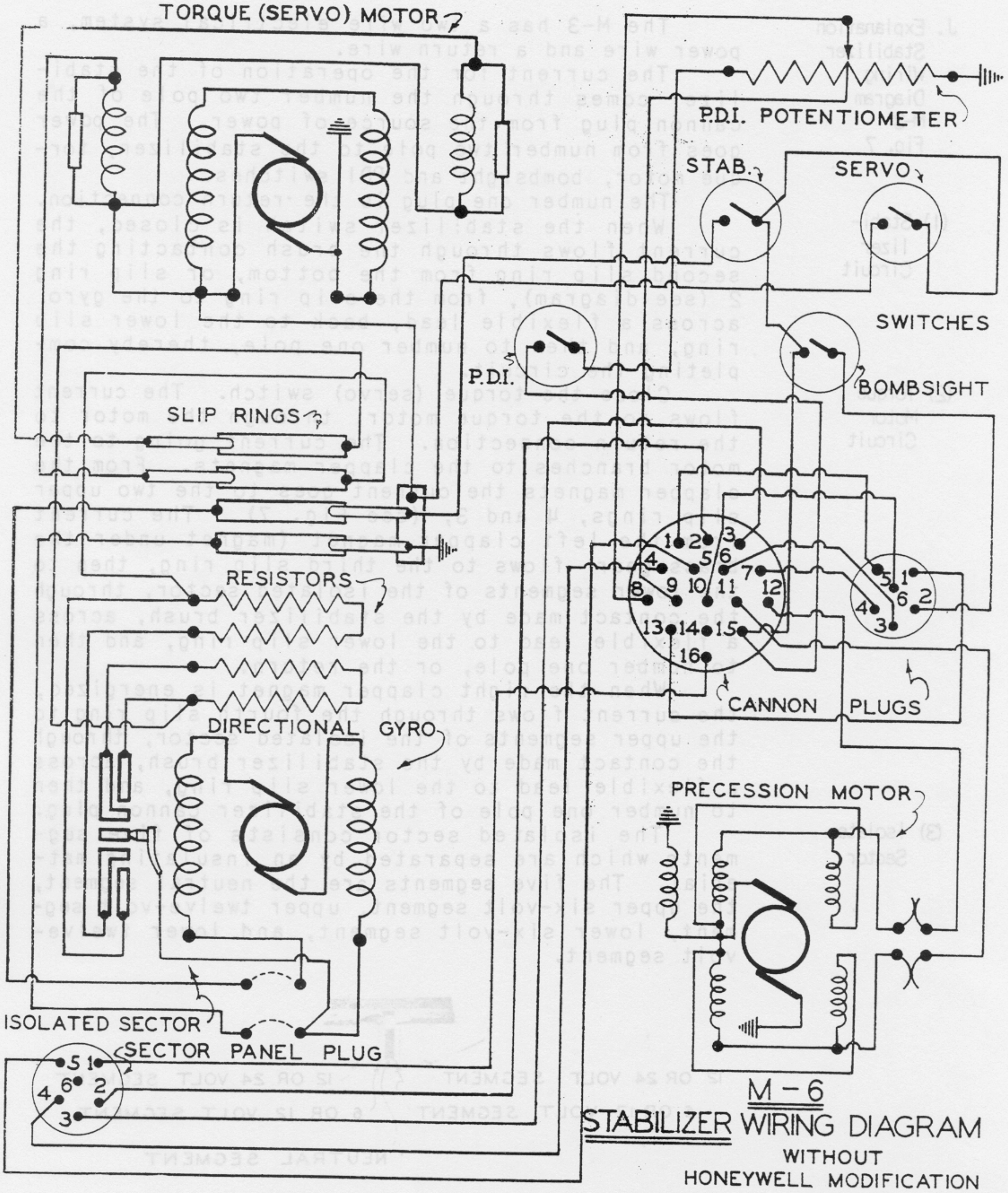

TORQUE (SERVO) MOTOR
P.D.I. POTENTIOMETER
STAB.
SERVO
SWITCHES
P.D.I.
BOMBSIGHT
SLIP RINGS
RESISTORS
1 2 3
4 5 6
7
8 9 10 11 12
13 14 15
16
5 1
4 6 2
3
CANNON PLUGS
DIRECTIONAL GYRO
PRECESSION MOTOR
ISOLATED SECTOR
SECTOR PANEL PLUG
5 1
4 6 2
3
M – 6
STABILIZER WIRING DIAGRAM
WITHOUT
HONEYWELL MODIFICATION

FIG. 9

The current from slip rings 4 and 3 passes directly to the upper and lower twelve-volt segments. Before the current reaches the six-volt segments, it passes through six-volt resistors.

The purpose of the six and twelve volt segments is to prevent hunting of the gyro across the neutral position.

When the gyro precesses a little off neutral, the brush contacts the six-volt segment, and one of the clutches is engaged and the gyro is precessed to neutral position. If the gyro precesses beyond the six-volt segment, more power is required to precess it back to neutral. When the brush contacts a 12-volt segment, the clapper magnet exerts more force upon the clutch engaged (until the brush reaches the 6-volt segment) and the gyro is precessed to neutral position.

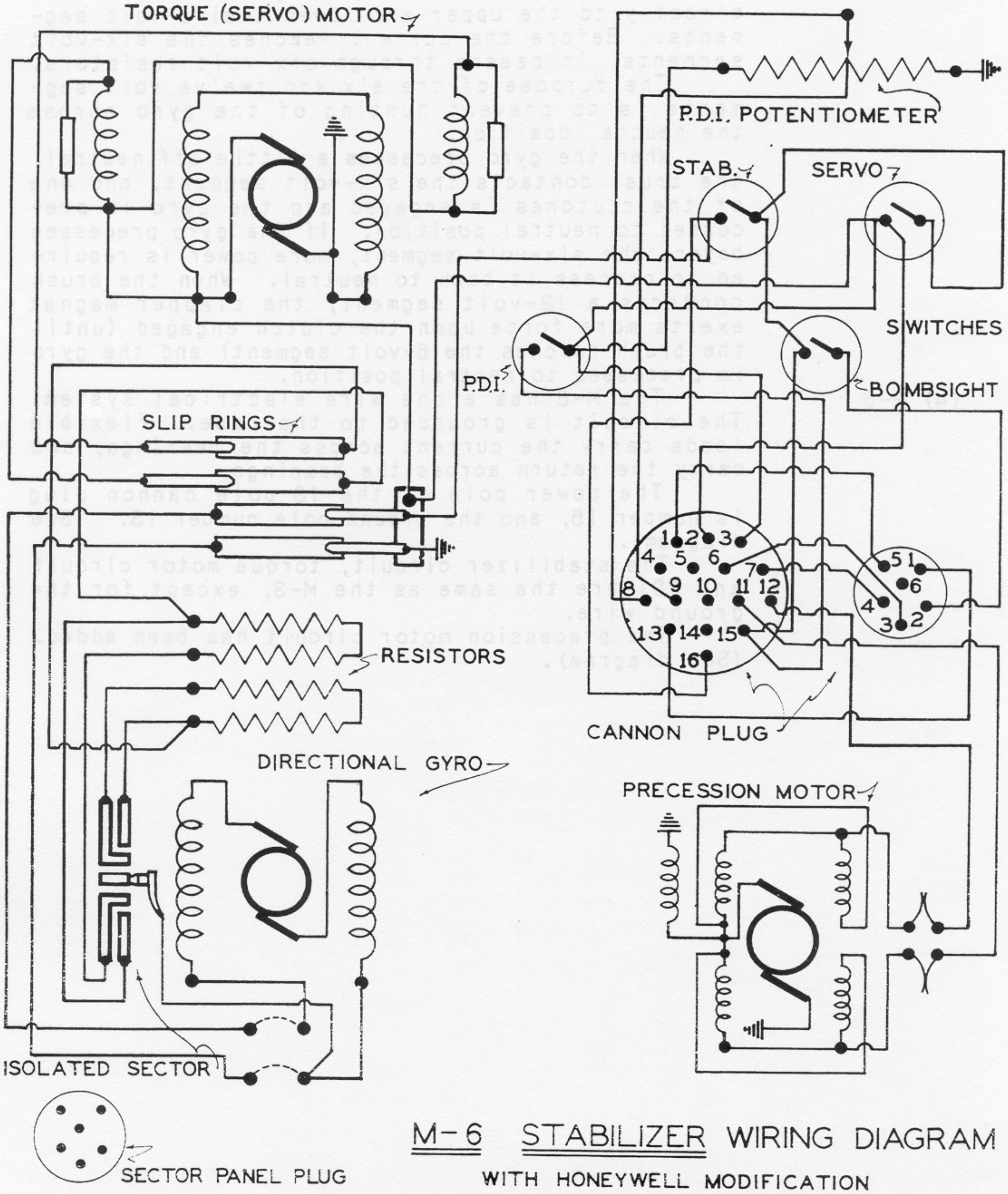
(4) M-6

The M-6 has a one wire electrical system. The circuit is grounded to the case. Flexible leads carry the current across the bearings, and carry the return across the bearings.

The power pole of the 16 pole cannon plug is number 15, and the ground pole number 13. (See diagram).

The stabilizer circuit, torque motor circuit and PDI are the same as the M-3, except for the ground wire.

The precession motor circuit has been added. (See diagram).



M-6 STABILIZER WIRING DIAGRAM

WITH HONEYWELL MODIFICATION

FIG. 10

K. M-6 Stabilizer Modification C.L.I. 42-6

When using the stabilizer with the Honeywell AFCES equipment, it is necessary to effect the following wiring modifications. The student should become thoroughly acquainted with these modifications, because they will be invaluable to him when he begins his study of AFCES.

1. Remove all wires from the number 5 plug. (Sector Panel)
2. Cut the number 2 wire short and solder to the dead side of the servo switch.
3. Remove the number 4 wire on the 16 pole plug.
4. Cut number 3 wire short and solder to dead side of PDI.
5. Use number 5 wire as a jumper from the dead side of the servo to the dead side of the PDI.
6. Cut number 16 wire short and solder to the dead side of the stabilizer switch.
7. Remove number 6 wire (in 6 pole plug), and number 10 wire (in 16 pole plug) completely.
8. Number 15 wire is hot lead.

STABILIZER ASSEMBLIES "M"- SERIES

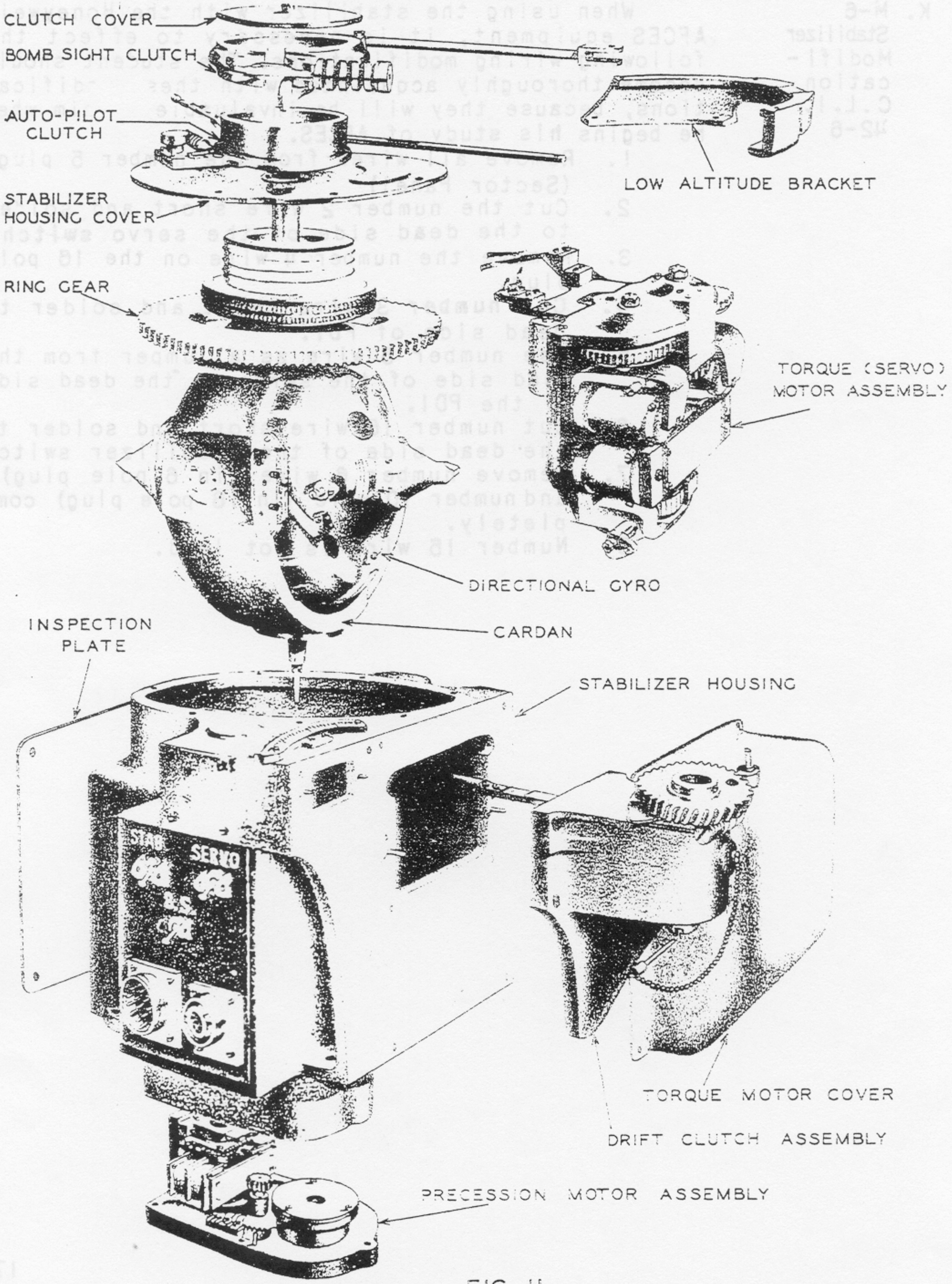


FIG. 11

SECTION II

DISASSEMBLY AND REASSEMBLY, STABILIZER

DISASSEMBLY

A. Inspection and Cover Plates

1. Remove rear inspection plate and torque motor cover, four (4) screws in each.

B. Bombsight and Auto-Pilot Clutches

1. Remove clutch cover plate.
2. Disengage bombsight clutch collar and remove from drum.
3. Disconnect auto-pilot connecting rod by removing two cotter pins and lifting rod off pins.
4. Remove hexagon nut from cardan gudgeon extension or male member of bombsight clutch.
5. Fit special clutch puller into clutch, tighten screws, tap lightly and clutch drum will loosen from gudgeon pin.
6. Remove puller.
7. Lift the bombsight clutch drum and auto pilot clutch off gudgeon.
8. Loosen and remove four (4) screws which attach auto-pilot clutch drum to bombsight clutch drum.

C. Precession Motor

Fig. II

1. The M-3 stabilizers are not all equipped with a precession motor; however, all M-6 stabilizers are.
2. Place stabilizer on table with the rear side down.
3. Remove the five (5) screws holding precession motor to stabilizer housing.
4. Set motor aside.
5. Remove two screws from precession gear and tap out straight pin and remove precession gear.

D. Top Cover

1. Remove two screws holding small inspection plate.
2. Remove eight (8) screws.
3. Work cover until bearing is released from shaft and remove cover.
4. If bearing needs cleaning remove the plate on top cover and felt washer, and remove bearing by tapping outer race lightly, using drift and mallet. Clean bearing, oil and replace.
5. Oil felt washer and replace.
6. Replace washer retaining plate.

E. Torque Motor

1. Disconnect directional gyro wire going to number 2 slip ring.

2. Disconnect wire to torque motor (isolated terminal).

3. On M-3 disconnect ground wire from lower slip ring (number 1).

4. Remove four (4) screws holding torque motor to stabilizer housing.

5. Work motor loose from dowel pins and remove torque motor assembly by tilting up and to the right, being careful of brushes and gears.

6. Set aside for later disassembly.

F. Drift Clutch

1. Rotate drift gear until hole is over center screw in drift clutch collar.

2. Remove screw. This disconnects the stabilized arm of the P.D.I. brush.

3. Remove four (4) screws holding drift gear assembly housing to stabilizer housing.

4. Work drift clutch assembly free from dowel pins and remove assembly.

G. P.D.I. Coil

1. Disconnect wire to A.E.S. disconnector button bracket (on units having A.E.S. disconnector attachment).

2. Remove four (4) screws in P.D.I. coil mounting plate.

3. Turn coil clockwise to free button from disconnector on stabilized arm.

4. Pull coil toward opening in housing.

5. Turn counter clockwise so that center top bracket will clear opening in housing.

6. Remove wires to coil and center bracket.

7. Disconnect wires to stabilized arm and remove arm.

H. Gyro and Cardan

1. Grasp, firmly, the projection of the cardan gudgeon and work cardan free of lower cardan gudgeon bearing.

2. Lift upward and tilt gyro so that bearing caps will clear the housing.

3. Be very careful when removing gyro and cardan so that ring gear is not damaged.

4. This assembly is heavy and if dropped serious damage will result.

I. Switch Panel

1. Remove four (4) screws attaching switch panel to stabilizer housing.

2. Remove switch panel.
   a. Check for loose connections or damaged wiring.
   CAUTION: Do not remove any wires.

REASSEMBLY
Fig. 11

A. Switch Panel

1. Reinstall switch panel.
2. Check shape of wires so that none will contact gyro and cardan assembly.
3. Insert screws and tighten.

B. Gyro and Cardan

1. Take a firm grasp of gyro and cardan assembly and reinstall in housing, tilting gyro so it will clear the top of the case.
2. Carefully but firmly seat lower gudgeon in lower bearing.
   CAUTION: Do not drop assembly into place.

C. P.D.I. Coil

1. Reinstall stabilized arm and attach wires.
2. Connect wires to coil and center bracket.
3. Insert end of resistance unit into housing.
4. Turn counter clockwise so the center bracket will clear opening.
5. Turn coil clockwise and push inward.
6. Turn counter clockwise so that A.E.S. disconnector button is positioned.
7. Insert screws in mounting plate and tighten.
8. Connect wire to A.E.S. disconnector button bracket.

D. Drift Clutch

1. Insert stabilized arm in fiber brush bracket.
2. Replace screw to hold arm in place.
3. Place drift clutch assembly on dowel pins.
4. Insert and tighten four (4) screws attaching assembly to stabilizer housing.

E. Torque Motor

1. Tilt assembly up and to the right so that the slip ring brushes and intermediate gear will clear ring gear. Position brushes on slip rings.

2. Place motor on dowel pins.

3. Insert and tighten evenly the four (4) mounting screws.

4. Connect wires to servo and stabilizer gyro wires. (Ground wire on M-3).

F. Top Cover

1. Replace cover.

2. Be sure that bearing is properly seated on the gudgeon.

3. Insert and tighten screws.

G. Precession Motor

1. Place precession gear on actuating shaft so that the hole in the gear and shaft are aligned.

2. Insert straight pin.

3. Replace screws and washers to hold pin in place.

> CAUTION: When removing and inserting the straight pin, be careful so that pin is not bent or precession gear damaged.
>
> Do not batter pin.

4. Reinstall precession motor.

5. Insert and tighten, evenly, the five (5) mounting screws.

H. Bombsight and Auto-Pilot Clutches

1. Place auto-pilot clutch collar on auto-pilot clutch drum.

2. Tighten four (4) screws fastening drum to bombsight clutch drum.

3. Place on upper projection of gyro cardan.

4. Tighten hexagon nut.

5. Place auto-pilot connecting rod on connection rod studs and replace cotter pins.

6. Replace bombsight clutch collar.

7. Replace clutch cover plate.

> NOTE: While rear inspection plate is removed check the shape of the flexible leads; also check for freedom of movement of the gyro and cardan.
>
> Shape pig tails on torque motor brushes; also clearance between the clutch plate and cork surfaced clutch gears. Clearance should be .003 to .005 of an inch (minimum clearance without drag).
>
> Plug in stabilizer and turn on one switch at a time and check operation of all units. Watch the voltmeter

and ammeter on the stand as you turn on the switches. If you have more than twelve (12) amps, turn the switch to off position immediately, or the flex leads may burn out.

1. Inspection And Cover Plates

1. Insert and tighten screws holding inspection and cover plates.

Overnight Settings

When the stabilizer is returned to the valut the following settings are made:

1. Bolt stabilizer to carrying stand.
2. Engage the clutches.

BOMB SIGHT CLUTCH DISASSEMBLY

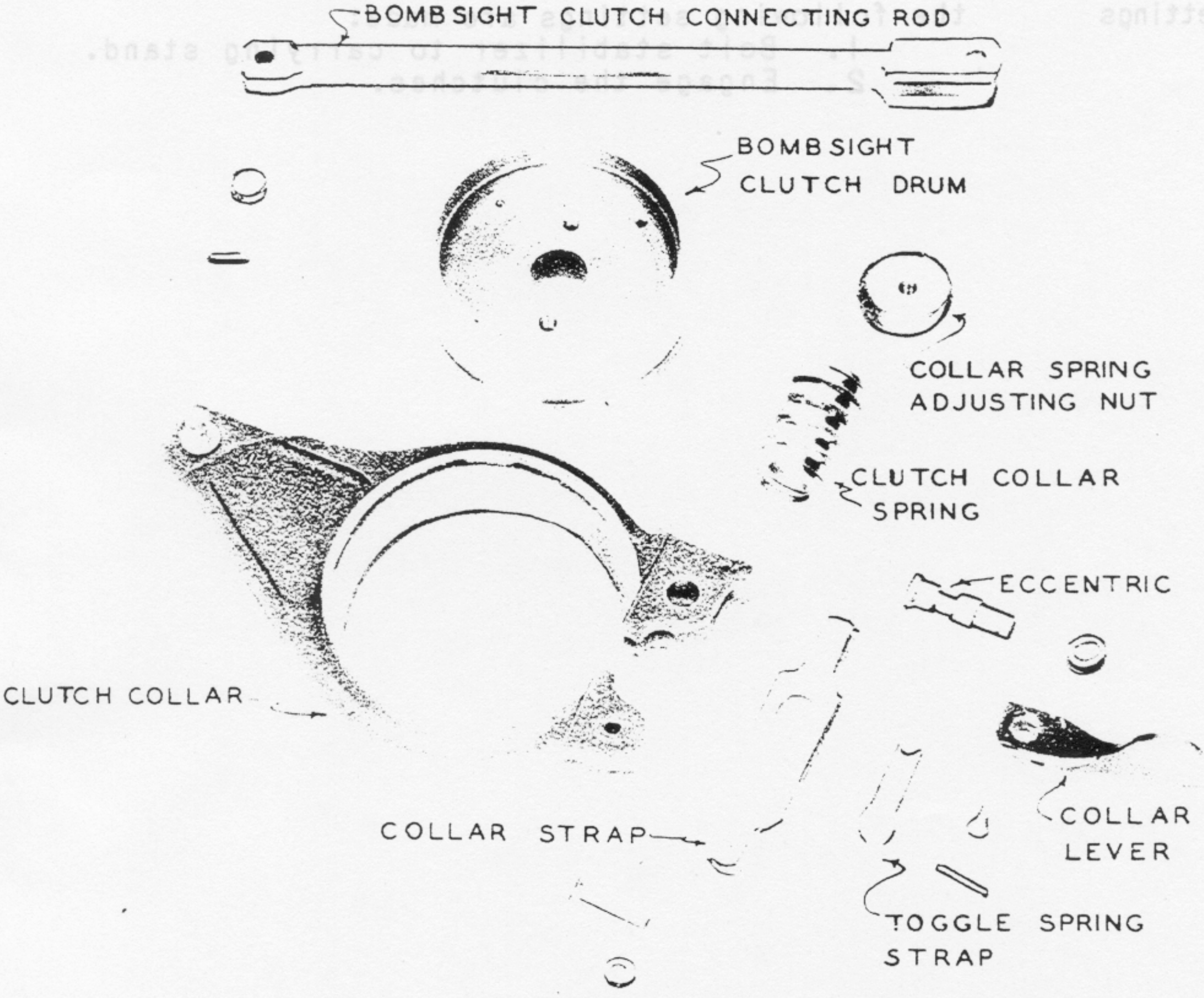


FIG. 12

SECTION III

DISASSEMBLY AND REASSEMBLY OF ASSEMBLIES, STABILIZER

DISASSEMBLY
AND
REASSEMBLY

A. Bombsight Clutch
Fig. 12

A. Disassembly

1. Tap out taper pin in bombsight clutch connecting rod stud.
   a. Remove collar
   b. Remove connecting rod
2. Remove collar spring adjusting nut and collar spring
3. Tap pin from clutch adjusting eccentric and collar lever
4. Loosen screw in collar lever and remove collar lever from eccentric
5. Remove eccentric
6. Tap taper pin from collar strap shaft
   a. Remove collar
   b. Tap out shaft
   c. Remove collar strap
7. Remove toggle spring strap

Whenever an assembly is disassembled always clean the parts and oil if necessary before reassembly. (See Section IV for maintenance).

B. Reassembly

1. Assemble collar strap and toggle spring strap.
2. Replace collar strap shaft, collar, and taper pin. (The punch marks on collar and shaft indicate large disc of taper pin hole)
3. Replace eccentric
4. Replace collar lever
   a. Line up pin holes and tighten screw
   b. Insert pin
5. Reinstall collar spring and adjusting nut
6. Place connecting rod on stud being certain that bevel of the clevis is toward stabilized sector of the bombsight.

AUTO-PILOT CLUTCH DISASSEMBLY

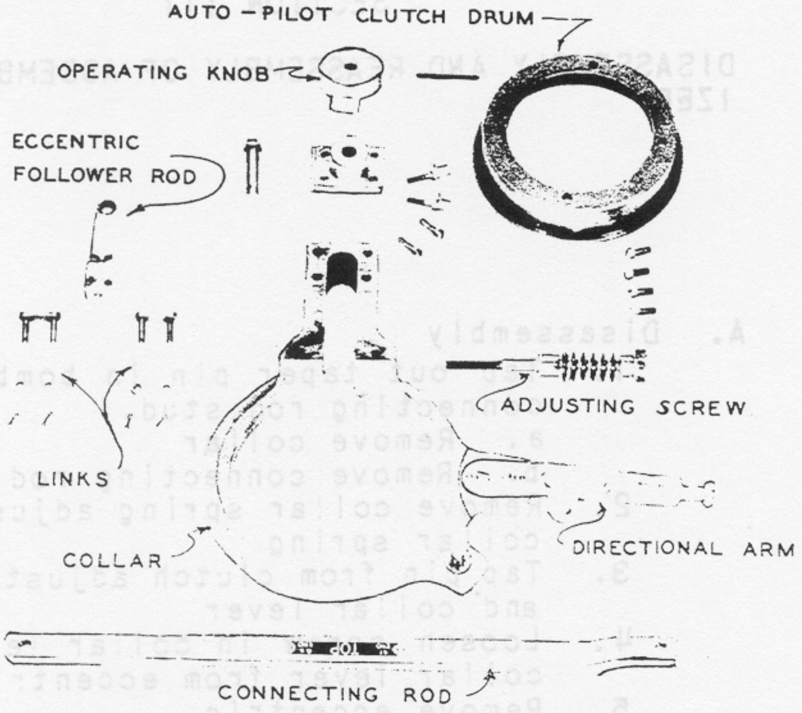


FIG. 13

DRIFT CLUTCH DISASSEMBLY

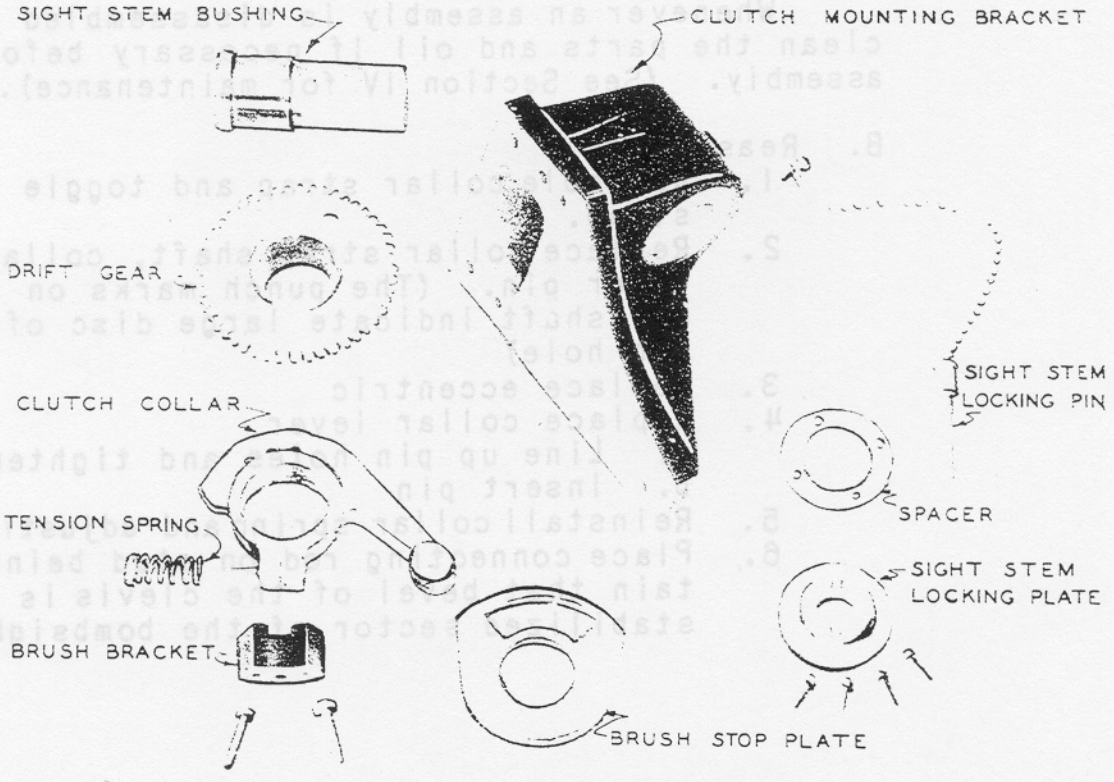


FIG. 14

B. Auto-Pilot Clutch

Fig. 13

A. Disassembly

1. Remove four (4) screws holding auto - pilot clutch drum to bombsight clutch drum.
2. Disengage clutch and remove drum.
3. Remove adjusting screw.
4. Remove four (4) cotter pins from eccentric follower block link pins.
5. Remove links and pins.
6. Tap straight pin from operating knob.
7. Remove four (4) screws holding eccentric bracket.
8. Remove eccentric and eccentric follower block.

B. Reassembly

1. Replace eccentric following block and eccentric.
2. Reinstall eccentric bracket.
3. Replace operating knob being sure that the stop on the knob is toward the clutch drum and the stop studs are diagonally across from each other.
4. Replace links and pins.
5. Replace cotter pins.
6. Replace adjusting screw and spring.
7. Place clutch collar on drum.
8. Reassemble auto-pilot and bombsight drum.

C. Drift Clutch

Fig. 14

A. Disassembly

1. Loosen tension adjusting screw.
2. Remove locking plate and spacer.
3. Use fiber drift and mallet to remove bronze sight stem bushing.
4. Remove drift gear from bushing.
5. Remove clutch collar from drift gear.
6. Remove stabilized brush stop plate.

B. Reassembly

1. Place clutch collar on drift gear.
2. Replace drift gear on bronze bushing.
3. Replace stablized brush stop plate.
4. Insert bronze bushing in housing. Use mallet to seat bushing.
5. Replace spacer and locking plate.
6. Tighten adjusting screw.

TORQUE MOTOR DISASSEMBLY

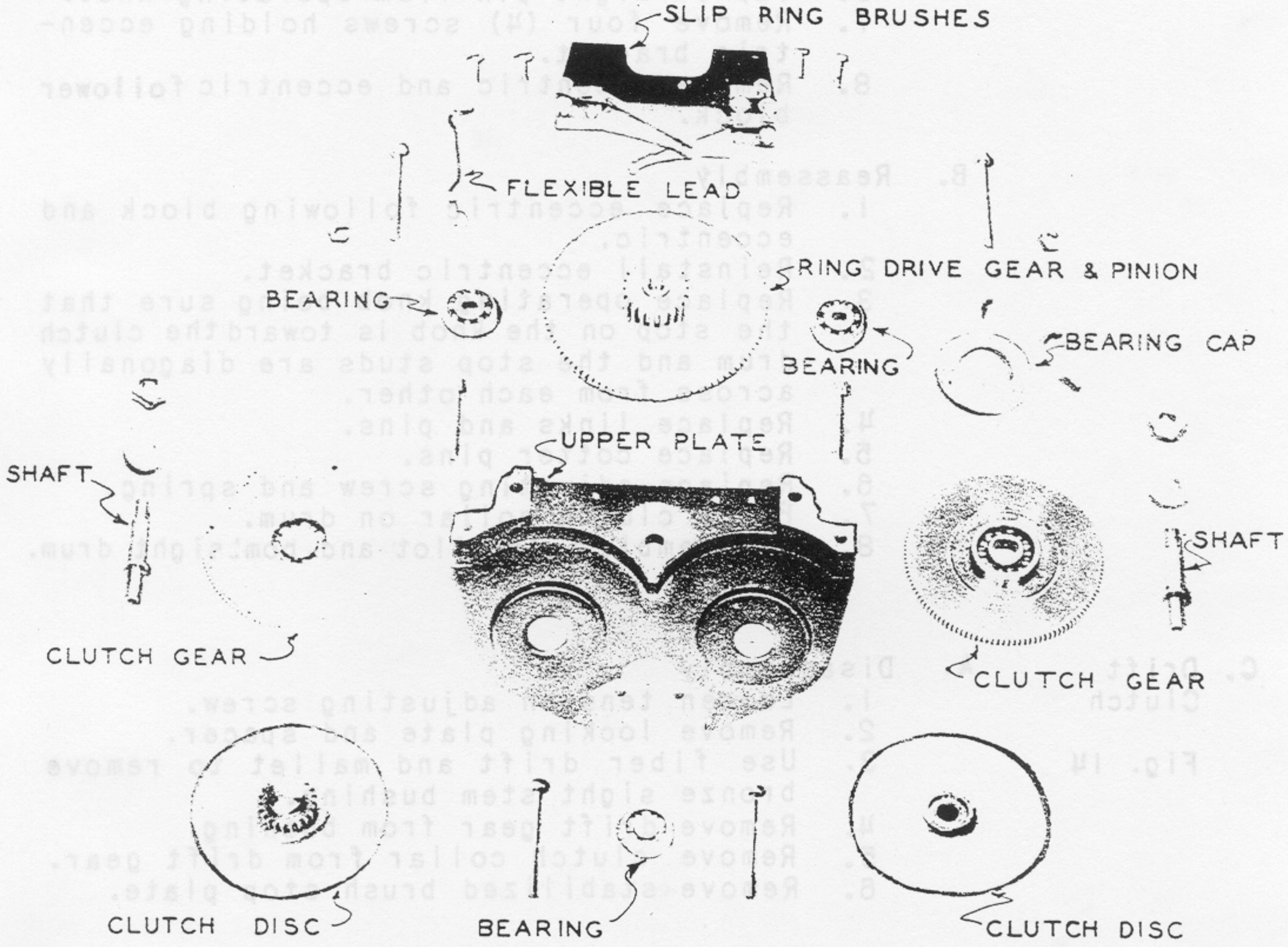


FIG. 15

D. Torque Motor

Fig. 15

A. Disassembly

1. Remove carbon motor brushes.
   a. Always disconnect terminal of pig tail from brush holder before removing brush; otherwise pig tail and terminal may be damaged.
   b. Mark brushes and brush plug nuts so they may be reinstalled in the same position from which they were removed.
2. Release wires from field coils, clapper magnets and slip ring brush terminal.
3. Remove slip ring brush holder bracket. (Fiber terminal block)
4. Take out the two bracket dowel screws (bolts) and four (4) filister head screws holding upper plate.
5. Tap gear shafts with fiber or brass drift to release shafts from bearings, and remove upper plate assembly.
   NOTE: When removing upper plate assembly do not damage clutch discs and ring gear drive gear. The clutch discs are free on the clutch gear shafts and if discs are dropped serious damage may result.
   a. Loosen and remove clutch gear shaft nuts and remove clutch gears.
      (1) If bearings are dirty remove the bearing clamp and with a fiber drift and mallet remove bearing.
         (a) Follow procedure for cleaning as outlined in Section IV, Maintenance.
6. Remove hinge pins and release clapper magnet armatures.
7. Remove two screws holding clapper magnets, remove magnets.
8. Take out the two long screws (field pole shoe bolts) that go through the field coils and remove shoes and coils.
9. To remove motor
   a. Tap taper pin from intermediate gear and remove gear.
   b. Remove the two screws attaching commutator and bearing bracket to base.
   c. Tap armature shaft free from upper bearing.
   d. Tap armature shaft to free from bearing in commutator end bearing bracket.

B. Reassembly

1. Replace motor.
   a. Insert armature shaft into upper

TORQUE MOTOR DISASSEMBLY (CONT.)

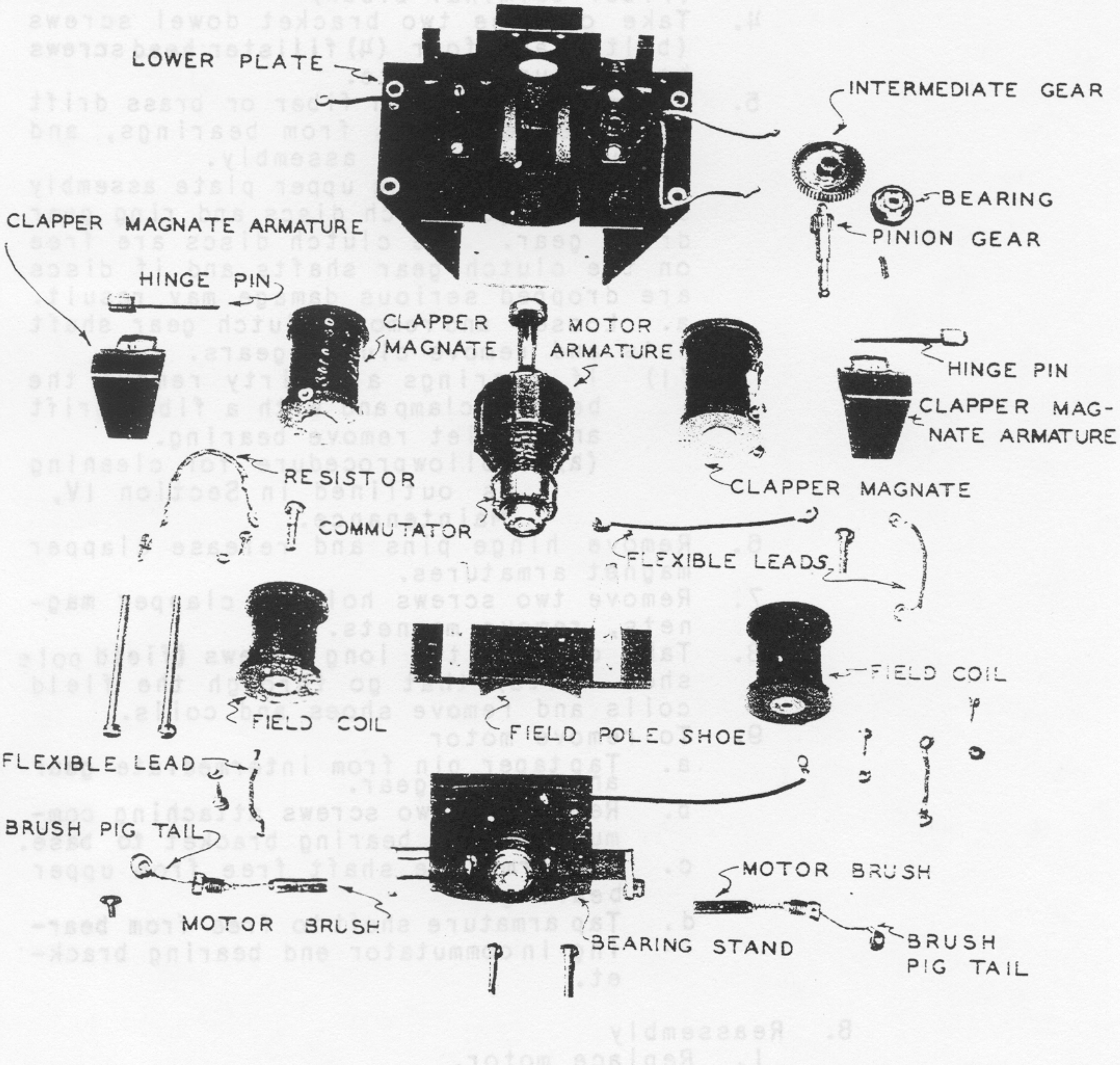


FIG. 16

D. Torque Motor (Cont'd)

Fig. 16

bearing and tap into place.

b. Place armature shaft in lower bearing and tap commutator end bearing bracket into place.

c. Replace and tighten screws, holding bracket to base.
   - (1) Check motor for freedom of movement.
   - (2) If armature does not turn freely, loosen screws and check alignment of bracket.

d. Replace intermediate gear and taper pin.

2. Replace field coils and shoes.
3. Reinstall clapper magnets.
4. Replace clapper magnet armatures and hinge pins.
5. To reassemble upper plate.
   - a. Insert bearing in clutch gear and replace bearing clamp.
   - b. Place clutch disc on shaft.
   - c. Place disc on smooth end of shaft.
   - d. Check to see that bronze and steel clutch gears are properly meshed.
   - e. Tighten clutch shaft nut.

     CAUTION: Do not tighten clutch shaft nut too tightly for the collar of the clutch gear shaft will be sheared.
   - f. Replace ring gear drive gear shaft in bearing, being certain that bearing is properly seated.
6. Replace upper plate.
   - a. The lower bearing of the ring gear drive gear is self aligning. Be sure that the bearing is properly aligned before tightening the screws and dowel bolts holding upper plate to frame. Rotate gears to check for freedom of movement. Gears should move freely; if not check work.
7. Replace fiber terminal block.
8. Replace carbon brushes. (Brush plugs should extend 1/4" from brush holder).
9. Connect all wires to the proper terminals.

Clearances to be checked after reassembly.

a. Clearance between clutch disc and cork insert .003 to .005 of an inch.

GYRO AND CARDAN DISASSEMBLY

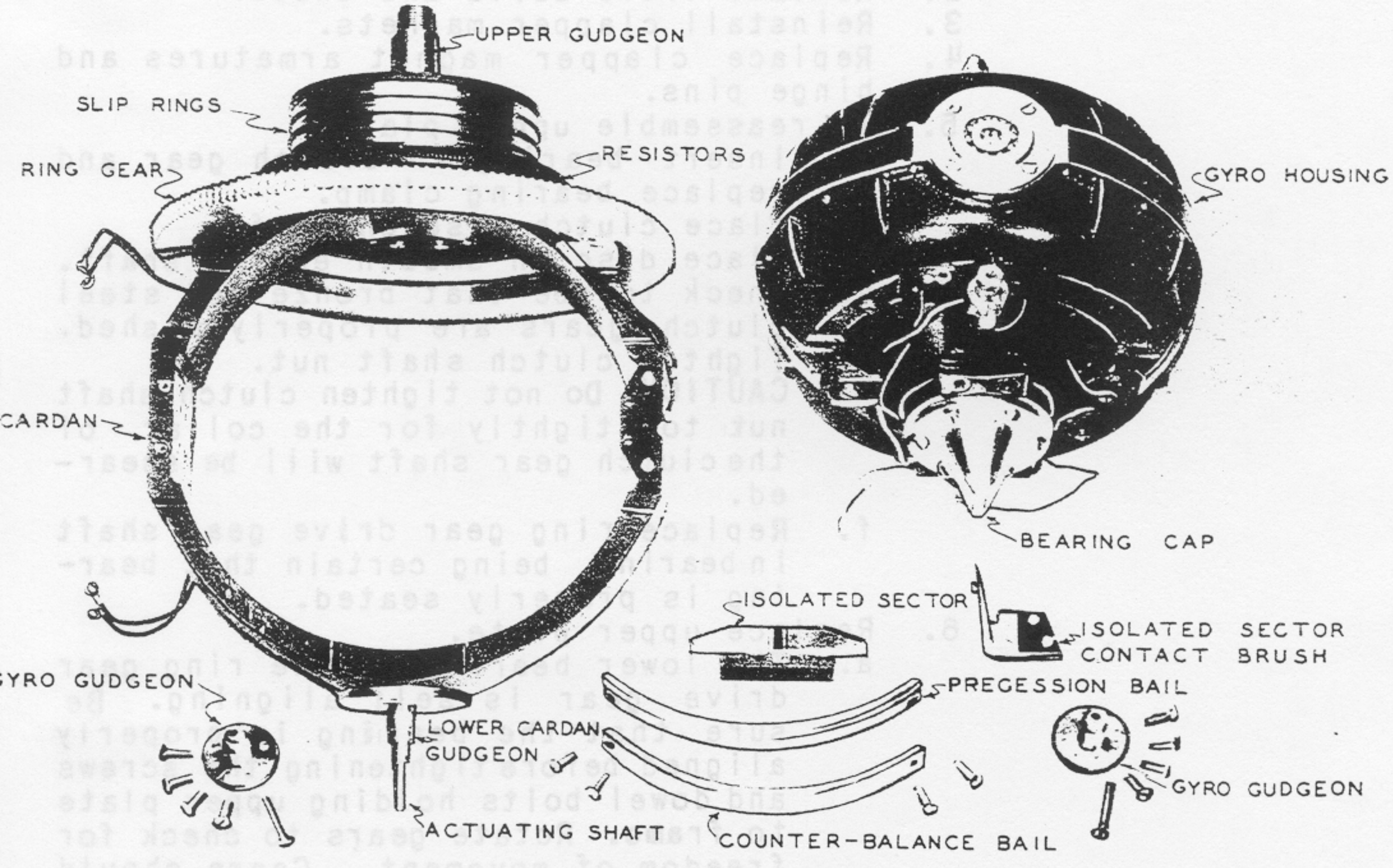


FIG. 17

STABILIZER GYRO AND CARDAN

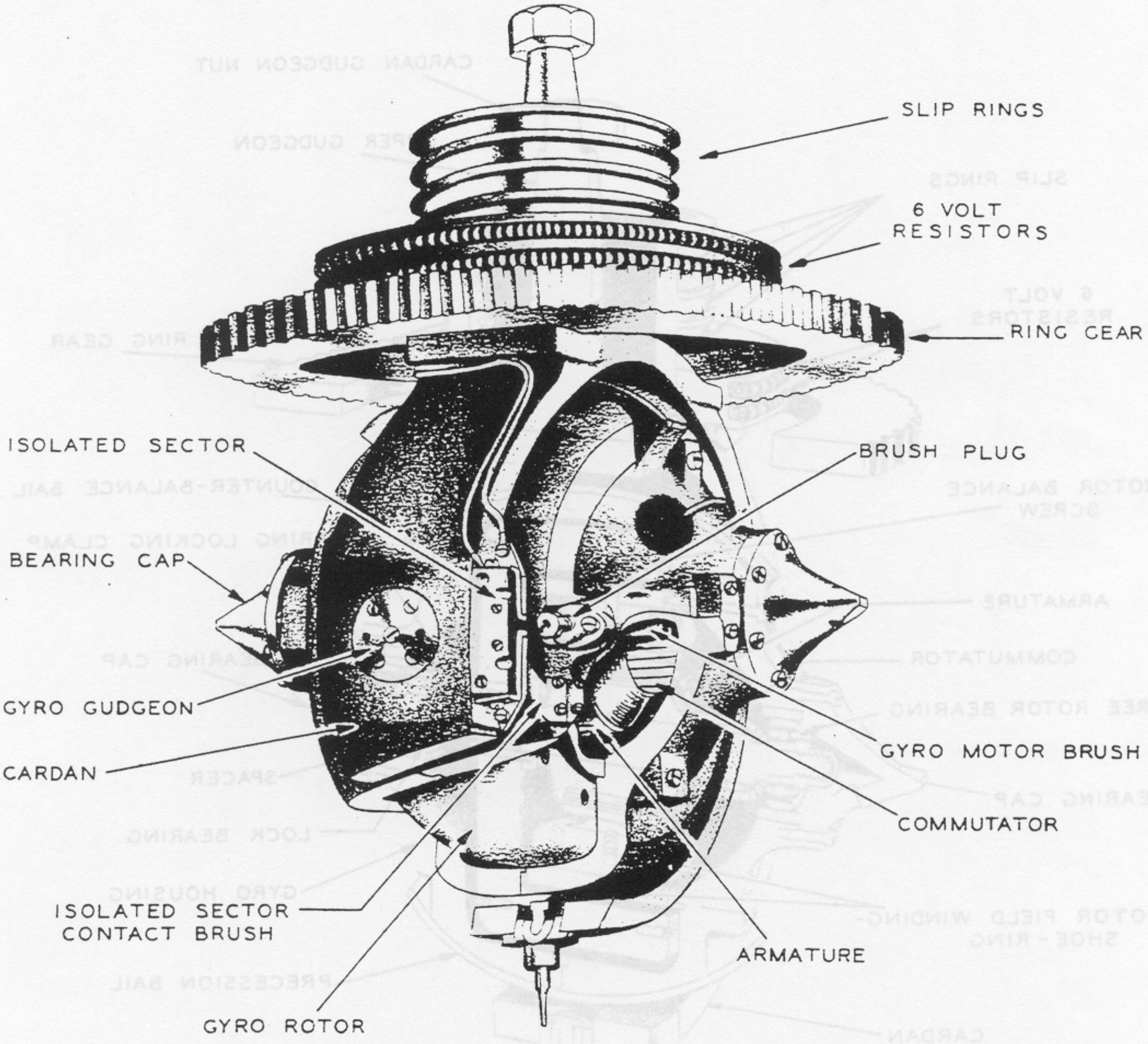


FIG. 18

STABILIZER GYRO AND CARDAN

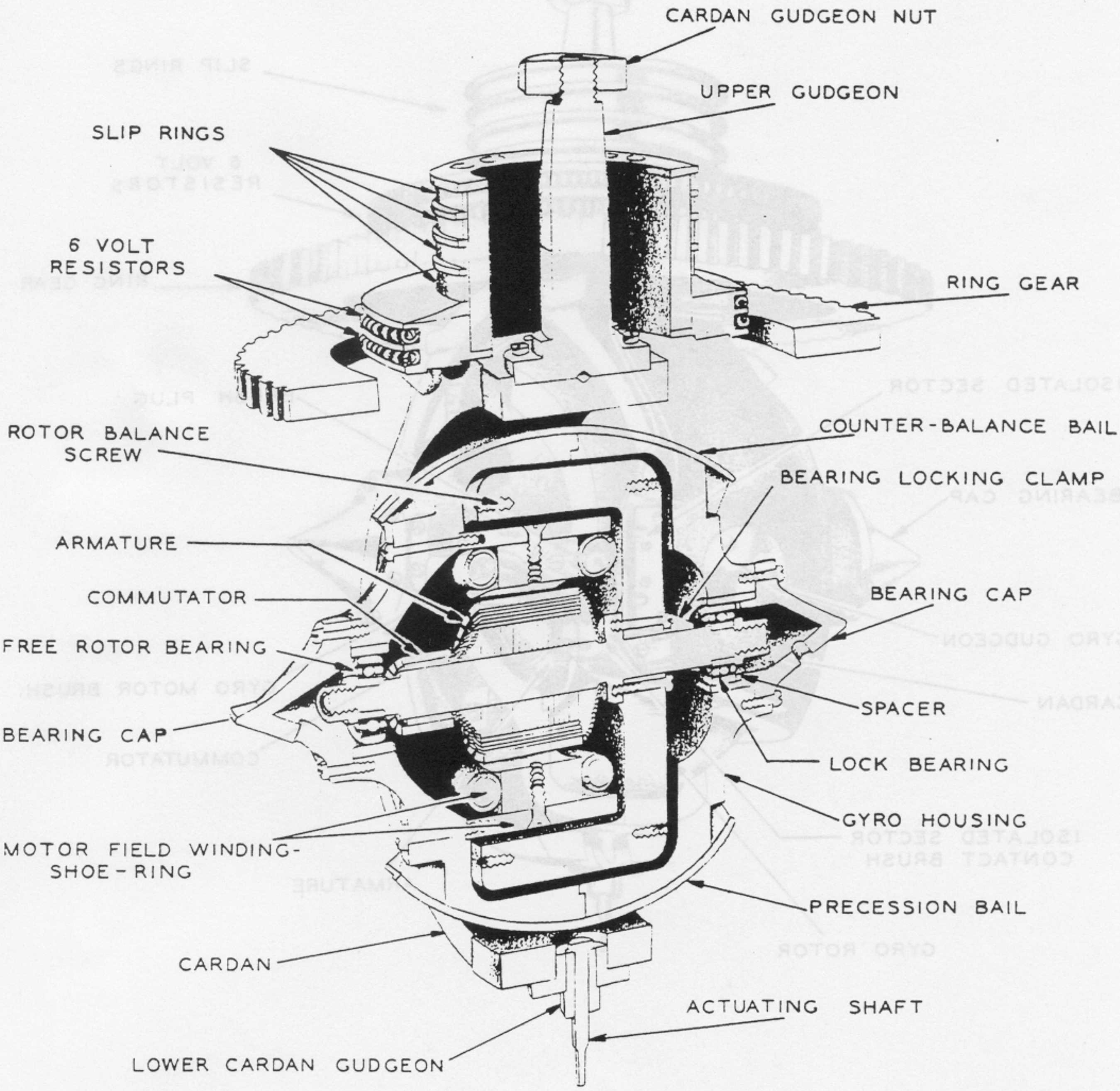


FIG. 19

   b. Air gap of 1/32 of an inch between clapper magnet and clapper magnet armature.
   c. Brush plug should extend 1/4" from brush holder.

E. Gyro from Cardan

Fig 17

A. Disassembly

1. Remove flexible leads.
2. Remove upper (counter-balance bail) and lower (precession bail) bails.
3. Remove isolated sector contact brush.
4. Remove center screw from gudgeons.
5. Remove the four (4) screws from each geon.
6. Use two in each gudgeon to pull the gudgeon.
7. Lift gyro from cardan.
8. Remove actuating shaft, clean, oil and replace.
9. Check bearings using jeweler's loupe.
   a. If the bearings are dirty remove and clean.
      (1) When removing a bearing always replace screws exactly as they were and never interchange bearings.
      (2) The following cleaning solutions may be used.
         (1) Tectyl No. 502
         (2) No Foam
         (3) L. & R. Rinse
             When using the above use in the order given.
         (4) Benzine
         (5) Acid-free kerosene
         (6) Alcohol

CAUTION: Never spin a bearing that is dirty. This damages the balls and race. A clean bearing will turn freely. After cleaning inspect bearing with a loupe.

Oil bearing after cleaning thoroughly and replace. Two (2) drops of oil are usually enough for the bearing; however, be certain that each ball has a film of oil on it.

See Fig. 20

If gudgeon bearings are removed to clean be certain that the locked bearing is replaced on the side next to the isolated sector. The bearing socket of the locked bearing has a flange which holds the bearing in place. The center gudgeon screw holds the bearing against the flange and the socket is fastened to the gyro case with four (4) screws. The bearing is thereby locked in its movement in relation to the gyro.

B. Reassembly

1. Replace bearings
2. Place gyro in cardan.
3. Insert gudgeons.

   CAUTION: When replacing the gudgeon pins, align the bearing with the gudeon by lifting and holding the gyro in place. The gudgeon should work freely. If one binds, remove and check for dirt and burrs.
4. Replace center gudgeon locking screw on locked bearing side. The locked gudgeon bearing on the stabilizer is next to the isolated sector. Always replace center gudgeon locking screw on locked bearing side first; otherwise the tension of the stabilizer brush on the isolated sector will be incorrect.
5. Insert four (4) gudgeon cap screws and tighten evenly.
6. Replace stabilizer brush, I. E. isolated sec sector contact brush.
7. Replace bails.
8. Connect flexible leads.

LOCKED GUDGEON BEARING

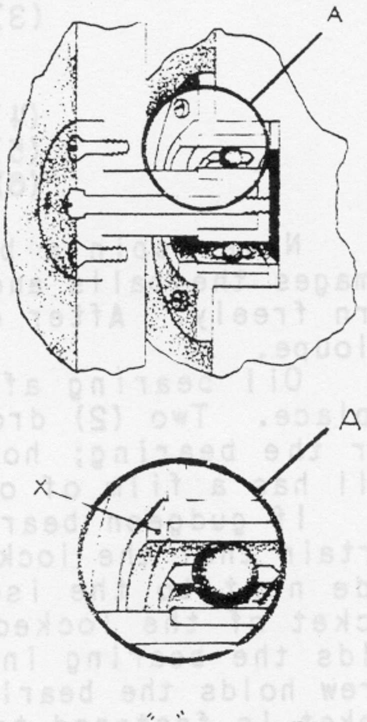


FIG. 20

SECTION IV

MAINTENANCE

GENERAL

A. Purpose

Proper maintenance of the bombsight equipment is necessary if that equipment is to function properly, and if the desired objectives are reached.

B. Definition

Maintenance may be defined as the proper care of tools and equipment to insure maximum efficiency and long life.

Three important items in maintenance are to keep the units 1. dry; 2. clean; 3. lubricated.

C. Handling
N.O.P.
#650
p. 6

Bombsight equipment is very delicate, and it must be protected from blows and rough handling. Great care must be exercised so as not to drop the equipment. Such an occurrance will ruin a sight or stabilizer or in any case will require extensive repairs at high cost and will necessitate withdrawal of the unit from service until such repairs can be made. The following precautions regarding handling of bombsights and stabilizers must be rigorously adhered to:

a. No man will carry more than one piece, bombsight, or stabilizer, at any one time.

b. There is always some danger in transferring the equipment in and out of planes, where footing is precarious. Here special care must be taken and the man receiving the unit must have a firm hold before the other lets go.

Special caution must be taken when the gyro is turning up.

C.L.I.
C-43-14

c. Any undo shock or jar may damage the bearings thereby upsetting the delicate balance of these instruments.

D. Log Books
N.O.P.
#650

The log book shall be studied by the student at the beginning of each session of the class. At the close of each session of the class proper entry shall be made in the log book by the student, and under the supervision of the instructor. Running time entries will be to the nearest five minutes.

The Bombsight Log is an official history of the bombsight from the time of its manufacture until it is withdrawn from service for survey. It is an official document and must be treated with the same care of making entries as any other log book. All entries except classroom instruction will be signed by a BSM officer.

The log book is self-explanatory so far as entries are concerned and no difficulty should be experienced in keeping it. It has been found from examination of log books which have been turned in with instruments for repair and overhaul that:

(a) A great deal of work is done on bombsights which is not entered in the log.

(b) Considerable upkeep work is performed by inexperienced personnel.

(c) There is a tendency to do more disassembly and adjustment than is necessary.

In order that the overhaul personnel may have a full knowledge of the condition of the equipment it is of the utmost importance that every adjustment or casualty be recorded clearly and fully in that log. It is only by cataloguing the frequency of casualties and adjustments that it is possible for personnel charged with design to have an indication of desired or necessary changes and be able to take steps to correct current designs, or instructions.

Whenever a bombsight is withdrawn from the service and turned in to the Supply Officer for storage or shipment, a notation will be made by the bombsight officer concerned as to the exact condition of the equipment. This notation will be made immediately following the last previous entry in the log book and will, in general, include the following information as applicable for guidance of the Supply Officer and others concerned:

a. This bombsight and/ or stabilizer is in serviceable condition for reissue without repair.

b. Thisbombsight and / or stabilizer should be forwarded to an overhaul shop for repair or overhaul prior to reissue.

c. This bombsight and/ or stabilizer has been lubricated and otherwise prepared for tempor-

D. Log Books (cont'd)

ary storage.

d. This bombsight and/or stabilizer has been lubricated and otherwise prepared for extended storage.

Whenever either the bombsight or stabilizer is turned in for overhaul or repair the log book must be forwarded with it.

In order to indicate to the shop receiving a serviceable sight, whether it has received any damage during shipment, the last precession chart accomplished should be inserted in the log book.

E. Overnight Settings

A. Stabilizer
1. Engage clutches
2. Fasten to carrying stand
3. Close vent

B. Sight
1. Cage gyro
2. Set stabilized sector arm under sight with bombsight connecting rod pin in sector (M-3 and M-6). Later modified units have pin attached to bombsight connecting rod.
3. Set trail arm at zero.
4. Set rate indicator off zero.
5. Set telescope to maximum sighting angle.
6. Set altitude knob at high altitude (minimum stop).
7. Raise prism (M-3).
8. Close vents (M-3).
9. All switches off.
10. Fasten sight to carrying stand.
11. "Clutch in" telescope clutch.
12. When removing from stand remove peep sight.

F. Inspections N.O.P. #650 P. 48

i. Pre-Flight Inspection

This inspection shall be performed each day at the beginning of each shift.

Only ten (10) or fifteen (15) minutes are required to make the pre-flight inspection on both sight and stabilizer, if the maintenance man is thoroughly familiar with the inspection.

I. Stabilizer Pre-flight Inspection

The following precedure should be followed in making a pre-flight inspection of the stabilizer.

1. Check the log book for imminence of periodic inspection and lubrication. (50-hour inspection and 15 hour inspection and 15 day lubrication).

2. Run stabilizer gyro and servo motor.
   a. Check servo motor action by engaging the bombsight clutch and moving the clutch in each direction manually. The directional gyro should hold its position in azimuth and the servo motor should hold the stabilizer brush or isolated sector contact brush at a neutral position up to the slippage point of the servo clutches. The servo motor clutches are adjusted to slip at a force of 32 to 36 pounds.
   b. Check clutch tensions of the drift clutch, auto-pilot clutch and bombsight clutch manually The tensions should be such that the drift clutch will be first to slip; then the auto-pilot clutch, and finally the bombsight clutch. These are rough checks but will serve to detect serious discrepancies in the clutch tensions; however, until the personnel has developed the sense of touch required to make a fairly accurate check of the clutch tension, he must always check the clutch tensions by use of the spring scales.
      The correct tensions are:
      1. Bombsight clutch should slip at a tension of 18 to 24 pounds.
      2. Auto-pilot clutch should slip at a tension of 10 to 12 pounds.
      3. Drift clutch should slip at a tension of 6 to 8 pounds.
3. Disengage clutches.
4. Turn off the servo and stabilizer switches.

2. Sight Pre-Flight Inspection

1. Turn on the bombsight switch
   a. Run sight gyro.
   b. Check coincidence of telescope pointers.
   c. Test P.D.I. action.
   d. Test search knob action.
   e. Test action of telescope drive clutch.
   f. Uncage the gyro and test action of the levelling knobs.
   g. Test telescope motor.
   h. Test automatic release.
   i. Check altitude knob for correct functioning and governing action at high and low speeds for each position of the disc speed change lever.
   j. If night bombing is contemplated, check the bubble and telescope cross-hair lights and rheostat.
   k. Test action of increased forward vision

knobs (Extra sighting angle).

l. Clean optics and glass as necessary.

m. Check action of course knobs and of rate and displacement knobs.

n. Check fit of locking pin.

3. Daily Inspection

1. Rotor Bearing will be checked for oil daily if the unit is exposed to the hot sun or the unit is installed in an airplane which has been sitting in the hot sun for a period of two hours or more. Do not oil excessively

2. Turn on all switches. Check operation of all moving parts.

CAUTION:

1. Check Voltage Each Time Sight Is Used.
2. After Oiling Bearings, Always Run Gyro About Ten Minutes and Clean Commutator and Brushes.

4. ~~15~~ 25 Hour Inspection

1. Visual inspection of case.
2. Check wiring for frayed insulation, loose terminals and loose connections.
3. Check clutches for tensions and operation. Clean if necessary:
   a. Bombsight
   b. Auto-pilot
   c. Drift-Clutch
4. Check for oiling and corrosion.

   If gyro rotor bearings are lubricated, run gyro for 10 minutes, remove brushes and clean commutator, brushes and brush tubes with carbon tet. Wipe with clean white dry cloth.
5. Inspect gears for burrs and dirt.
6. Check isolated sector and contact made by stabilizer brush.
7. Check slip rings and contact of slip ring brushes.
8. Check telescope light.
9. Check action of all moving parts.
10. Clean glass.
11. Clean disc and roller.
12. Check disc speed.
13. If, during check, there is indication of malfunctioning find trouble and correct.

If a 15 hour inspection is performed, the accumulated number of days for the next 15 day inspection will be dropped and started from zero.

5. 15 Day Inspection

Inspect gyro rotor bearings each 15 days when gyro has been operated less than 15 hours in 15 days. Oil if necessary. See 15 Day Insp. Maintenance, Sight for further instruction.

6. Fifty Hour Inspection

a. Case or Housing N.O.P. #650 C.L.I. 42-26

1. The case must be kept clean and dry to prevent corrosion. Check condition of paint as to peeling, chipping, etc. If the paint has been chipped or has peeled but no corrosion formed, scrape and polish area with a hard wooden stick and crocus cloth and retouch with a fast drying crackle finish lacquer on the exterior, and black mat finish on the interior. If corrosion has formed underneath pain, scrape and polish area thoroughly before retouching. Corrosion of the magnesium alloy in the equipment may be detected as a white powder or paste similar to the substance which is found on a "dead" dry cell battery. It must be removed completely by scraping it away to the bare metal. Retouch with black paint or run in a small amount of bombsight oil if no paint is available.

2. Check for corrosion around screw heads. If corrosion is found it is the case, not the screw, that is corroded; all screws are either brass or stainless steel. Too much emphasis cannot be put on the fact that most screws are small, soft, and the threads are delicate, both on the screw and in the hole. Always remember that you are working on an extremely delicate instrument. To avoid corrosion of screw holes,, dip each screw in light oil before replacing. Do not dip the screw in your mouth.

3. If the case is dented or cracked to such an extent that the operation of any unit is impaired, the condition should be reported to Chief A. F. Maintenance Command and method of disposition requested.

4. Remove dirt from interior of case with alcohol moistened cotton an a swab stick. NEVER TRY TO BLOW THE DUST AND DIRT FROM THE INSIDE OF THE CASE.

5. Check for corrosion and rust on the bare metal. Remove condition with acid-free kerosene and crocus cloth. Clean the surface thoroughly with benzine and dry with a clean white cloth. Use of clean white cloths in connection with this equipment is stressed, due to the fact that the dye from colored cloth may easily be deposited upon the surfaces with which it comes in contact

when used in conjunction with oil, solvents and etc.

b. Electrical Wiring Stabilizer

1. Check for frayed or burned insulation, or faulty terminals. Replace damaged parts, first remedying the cause of the trouble.

2. Check terminal screws for tightness, stripped threads and bad screwdriver slots. Replace where necessary.

3. Check for proper shaping of all wiring. This includes pigtails and flexible leads. The flexible leads on the stabilizer are heart shaped. The flexible lead must not touch any part of the housing or gyro case, except at the terminal connections. Just prior to making a precession run the flexible leads must be shaped and then left alone. If they do touch, they will be shorted and will burn out. The pig tails are shaped so that they enter the brush plug at 180° angle. This permits the brush to adjust itself to the commutator and prevents the pig tail from binding on the brush plug. The pig tail is curved from plug to the terminal and shaped so that it will not touch the gyro or stabilizer housing as the gyro precesses.

4. Check continuity of all units through switch panel. Mount the stabilizer on the calibration stand. Contact plus and minus terminals in stabilizer cannon plug, poles 2 and 1 respectively. With the prods of the ohmmeter set on poles 2 and 1, turn on one switch at a time and note the resistance in ohms for each circuit.

DO NOT HAVE CURRENT TO THE EQUIPMENT WHILE USING THE OHMMETER TO CHECK RESISTANCE.

Compare the reading obtained with the chart given below. Not enough resistance denotes a short circuit; too much resistance indicates faulty connections, dirty termmnals, loose terminals and, in some instances, broken wires making partial connection.

c. Average Resistance Chart-A-3 Stabilizer

Switch Positions and Terminals Contacted	Average
1. Stabilizer switch "on". Contact poles 1 and 2.	13.5 ohms
2. Servo switch "on". Contact poles 1 and 2.	4 ohms
3. P.D.I. switch "on". Contact poles 1 and 2.	130 ohms

CHECK CONTINUITY
WITH VOLT-OHM METER

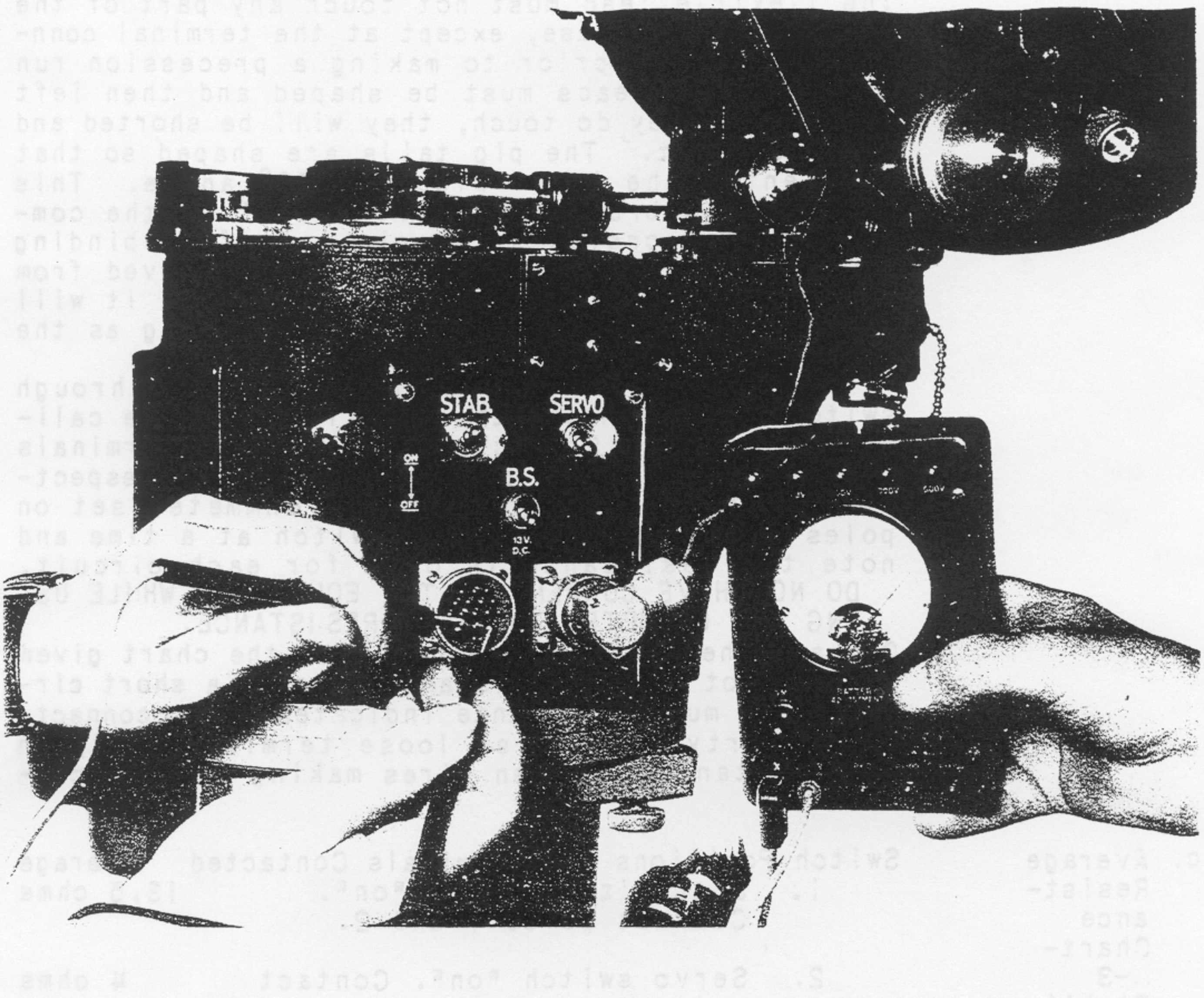


FIG. 21

	4. P.D.I. switch "on". Move P.D.I. brush to each stop and contact poles 5 and 6.	Readings should be equal in each direction.
M-6 Stabilizer	1. Stabilizer switch "on". Contact poles 12 and 15.	12 ohms
	2. Servo switch "on". Contact poles 13 and 15.	3 ohms
	3. P.D.I. switch "on". Contact poles 13 and 15.	3.5 ohms
	4. P.D.I. switch "on". Move P.D.I. brush to each stop and contact poles 8 and 9.	Equal readings in each direction.

d. Gears, Stabilizer

1. Check all gears for burrs, and remove the burrs with a knife-edge Arkansas Stone. The Arkansas Stone chips easily; so when using it, stone the gear teeth parallel with the groove and do not apply an angular pressure on the stone.

2. Clean all gear teeth with an orange stick, and brush with benzine, or other suitable solvent. If brush is used, dirt and solvent should be caught on a cloth held next to the gear being cleaned so that other parts will not be affected.

SPECIFIC UNITS

6. Fifty Hour Inspection (Cont'd)

1. Clean each of the clutches, bombsight, auto-pilot and drift clutch, with benzine, alcohol or carbon tetrachloride. Wipe dry with clean white cloth. Oil all working parts with "L" grade bombsight oil and remove all surplus oil. The friction or clutching surfaces should have a film of oil rubbed into the metal and then remove all the oil with a clean cloth. The oil that remains in the pores of the metal will not affect slippage and will prevent corrosion. The clutches will be cleaned monthly whether stabilizer has 50 hours running time or not. Local conditions will also determine how often the clutches must be cleaned to keep them working properly.

CHECK CLUTCH TENSIONS

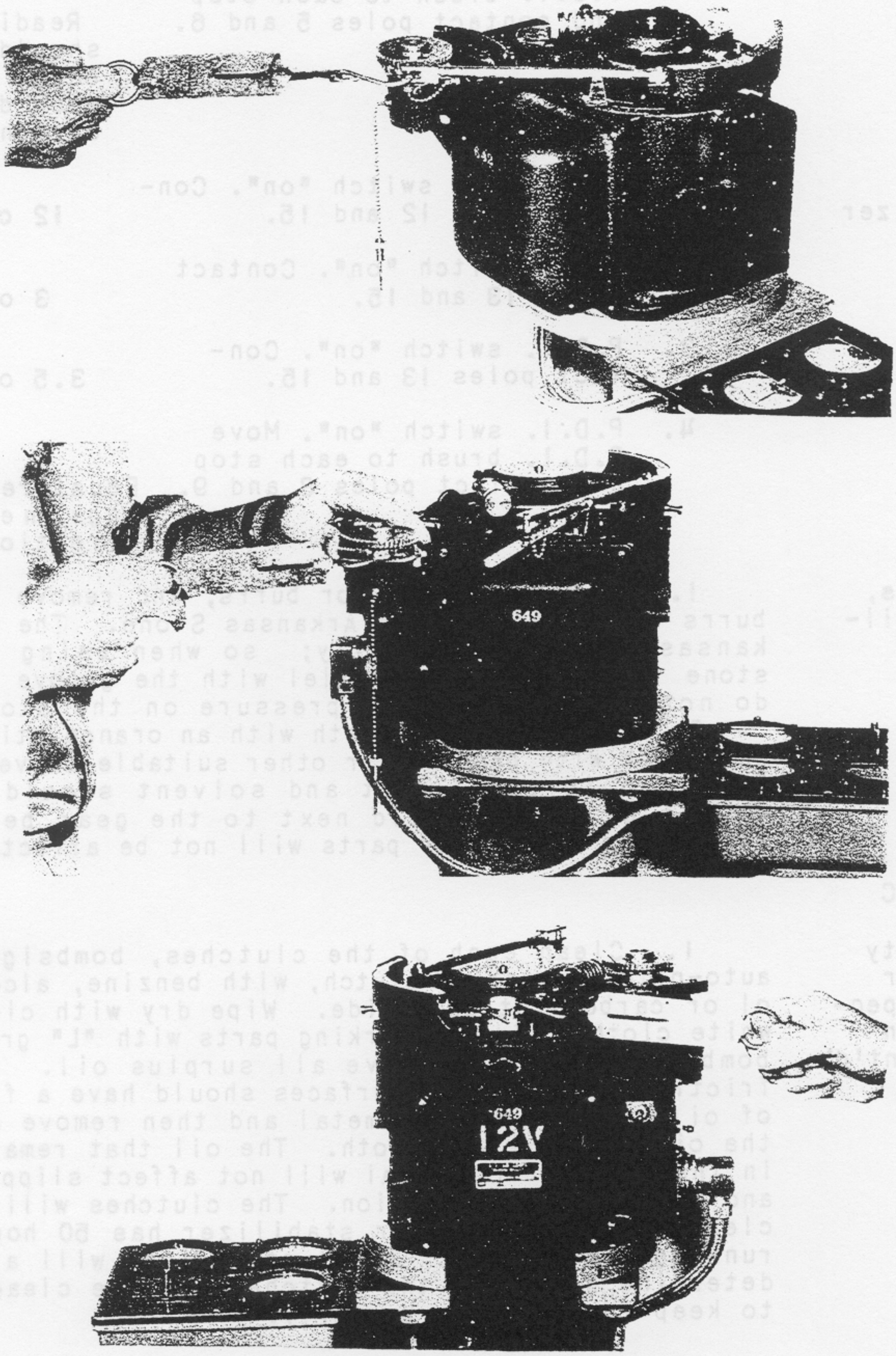


FIG. 22

a. Clutches

Fig.22

Fig. 3

Never use an abrasive on the clutch surfaces.

2. After cleaning and oiling the clutches, adjust and check the tension at which each clutch slips.

a. The bombsight clutch should slip at 18 to 24 lbs. Clockwise rotation of the collar spring adjusting nut will increase the tension, counter-clockwise rotation will decrease the tension. When checking the tension have the two marks on the bombsight clutch connecting rod coinciding with the edges of the connecting rod clamp bracket.

b. The auto-pilot clutch should slip at 10-12 lbs. Tension adjustment is obtained with adjusting screw and spring.

c. The drift clutch should slip at 6-8 lbs. Adjust with slotted nut on end of screw. (Tension adjustment).

d. When checking the above tensions, have the gyro wedged and servo running. Pull at right angles to radius to which scale is attached. Attach scale to following points:

1. Bombsight clutch connecting rod pin in outer end of bombsight clutch connecting rod.
2. Auto-pilot clutch operating knob.
3. Drift clutch; auto-pilot connecting rod stud.

b. Directional Gyro and Cardan

1. Oiling

a. Inspect gyro rotor bearing; if dry, place one drop of heavy bombsight oil directly on the balls of each bearing. WARNING: DO NOT TOUCH APPLICATOR TO ANYTHING.

Oiling N.O.P. #650 Fig.23

b. When removing stabilizer bearing caps punch screws through paper and mark so that they can be replaced in their correct positions. Watch for the lock washer in the bearing opposite the commutator because it sometimes sticks to the bearing cap. Check to see that the washer is installed before replacing the bearing cap.

c. During operation all oil except a light film on each ball is thrown out. To check for this film, on the stabilizer bearings, drag a dry hair across one ball. If the hair sweeps off clean, the ball is dry and the bearing needs oil. If the hair follows the contour of the ball, the bearing needs no oil. A cigarette paper may be

CHECK ROTOR BEARINGS LUBRICATION

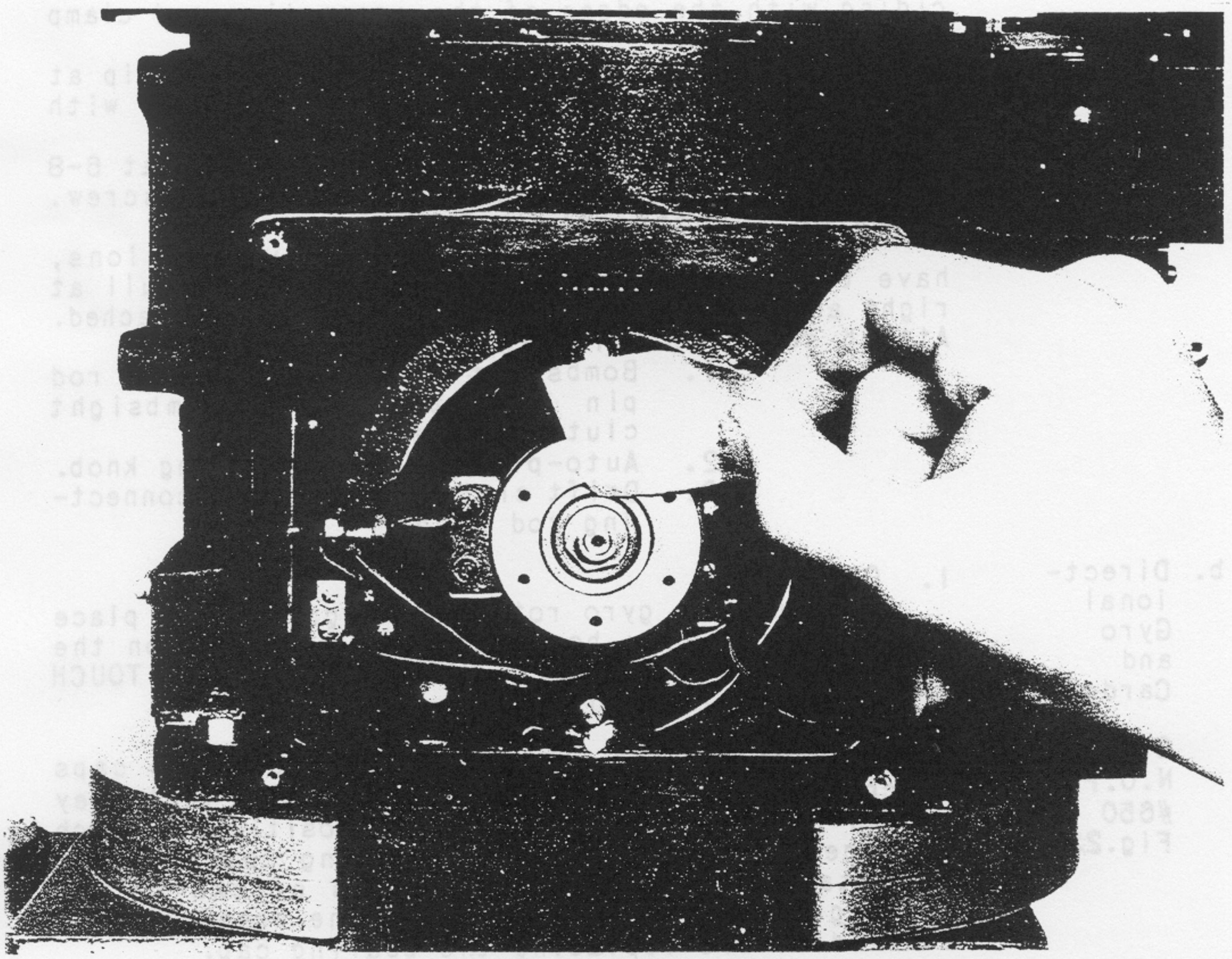


FIG. 23

used. In no other instance will the balls of a bearing be touched by anything. (When one rotor bearing is oiled always oil the other rotor bearing: (if one bearing needs oil so does the other).

d. Check the log book for running time of the stabilizer gyro. Weather conditions and mechanical operation of the gyro must be taken into consideration. The maintenance man should not attempt to oil these bearings with a syringe until he is expert enough to apply just enough pressure to the syringe to obtain one and only one drop of oil, with his eyes closed.

e. During operation all excess oil is thrown off in a fine spray. This spray settles on the commutator and brushes. Oil on the brushes causes them to soften and chip. Carbon dust and metal from the commutator settles into the bearings and will cause serious damage to them. To prevent this, it is very important that the commutator and brushes be thoroughly cleaned immediately after oiling.

f. Replace bearing caps and run gyro for approximately 10 minutes, then wipe off the excess oil that has been thrown out.

g. Clean commutator, brushes and brush tubes.

PRECAUTIONS:

1. Use correct amount and grade of oil.
2. Do not apply oil while unit is moving.
3. Do not touch the applicator to anything, for dirt will be transferred to the oil, and thence to the bearing. The applicator will also scratch the balls.
4. Place oil directly on balls between the inner and outer races, where possible.
5. Run unit for 10 minutes.
6. Clean brushes and commutators.

b. Directional Gyro and Cardan (Cont'd) Cleaning

Fig. 18 pg. 33

2. Cleaning.

a. Gyro must be stopped to clean.

b. Before removing brushes, scribe head of brush plug and measure the amount it extends from the brush tube. This will make replacement of the brush and plug to the same position more exact. Mark them in such a way so that on replacement they are in the same position as before.

c. Use clean white cloth moistened with carbon tet. or benzine (not alcohol) over the end of a soft wood stick, for cleaning commutators.

STABILIZER GYRO AND CARDAN

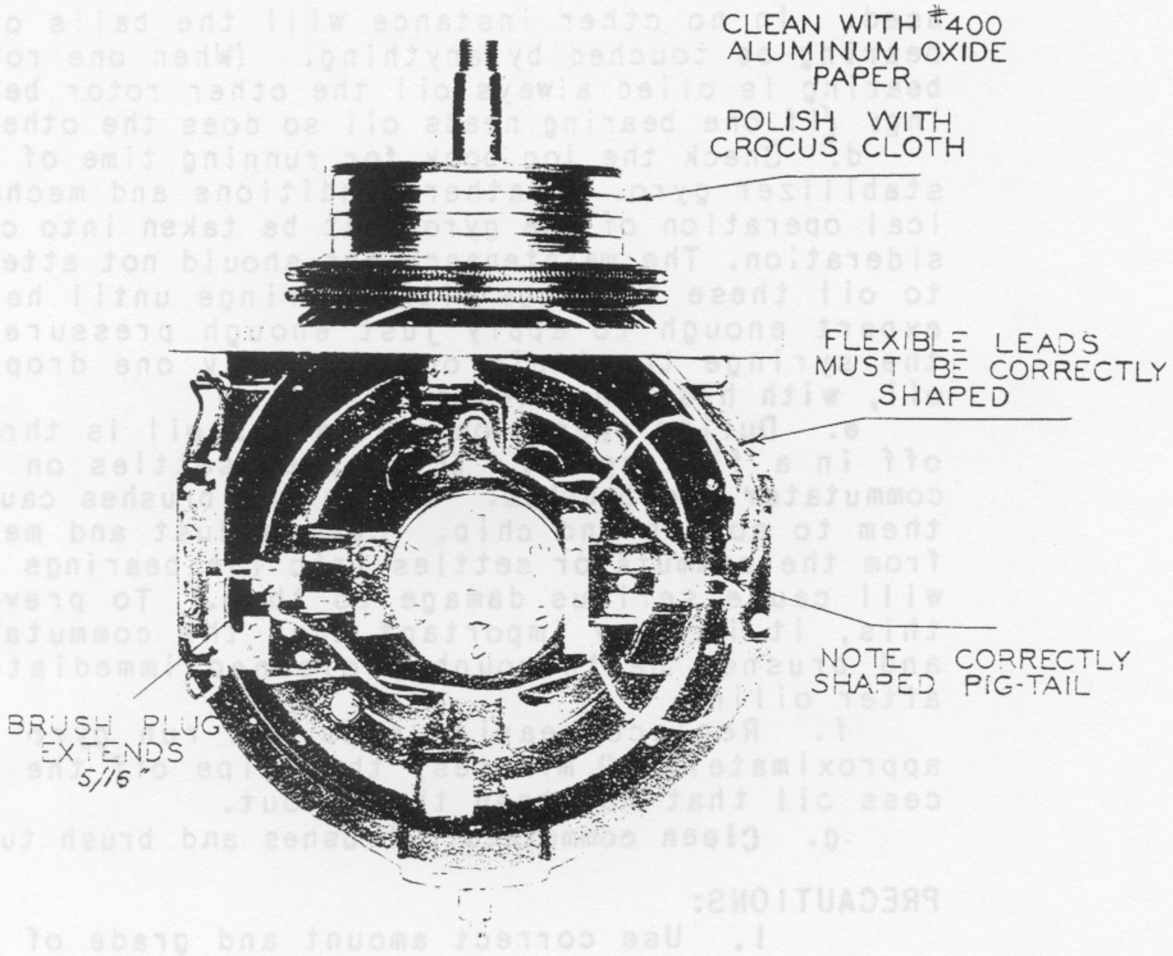

CLEAN WITH #400 ALUMINUM OXIDE PAPER
POLISH WITH CROCUS CLOTH
FLEXIBLE LEADS MUST BE CORRECTLY SHAPED
NOTE CORRECTLY SHAPED PIG-TAIL
BRUSH PLUG EXTENDS 5/16

FIG. 24

ISOLATED SECTOR

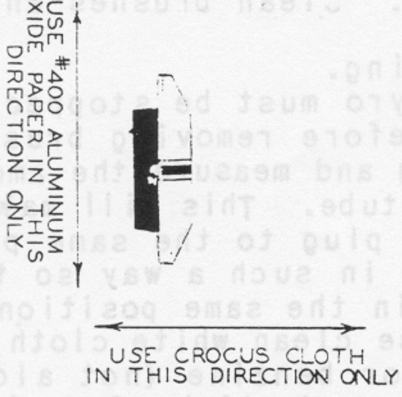

USE #400 ALUMINUM OXIDE PAPER IN THIS DIRECTION ONLY
USE CROCUS CLOTH IN THIS DIRECTION ONLY

FIG. 25

Keep using a new section of the cloth until cloth comes out clean after being in contact with the commutator. Scrape between segments (away from bearing) with wedge pointed orange stick. Never use metal stick of any kind for holding cloth on commutator.

d. Use very small amount of alcohol or carbon tet. for cleaning brushes and brush tubes. Do not use benzine.

e. If the commutator is rough or grooved, the gyro should be disassembled. Use #400 aluminum oxide paper to remove roughness and grooves. Care must be taken or the commutator may be tapered or hollowed. Always check to make sure the commutator is not out of "round". If it is tapered or hollow in spots, the commutator must be turned down on a lathe; otherwise the gyro would be out of balance and the low spots would cause arcing and pitting of the commutator.

CAUTION

Never use an abrasive on the commutator while it is installed in the gyro case. Some of the abrasive will be deposited on the bearings and serious damage to the bearings will result. When an abrasive is used on a commutator, the commutator should be rotating on its own bearings or in a lathe. After an abrasive has been used on the commutator, always remove the burrs between the segments with #400 aluminum oxide paper and clean with a white cloth moistened with carbon-tet. If carbon-tet, is used the commutator must be cleaned with a clean, dry cloth to remove crystaline residue.

f. If the commutator is pitted it should be turned down in a lathe on its own bearings by an experienced machinest. (This is a depot or factory job.) If the commutator is worn, in the stabilizer, so that correct gyro speed cannot be obtained, or if proper precession is impossible, report the trouble and await disposition.

Speed of Stabilizer Gyro

The stabilizer gyro turns approximately 8000 plus or minus 400 r.p.m. when operating on 13.5 volts.

Replacement of Carbon Brushes, Stab. Fig. 24

1. Carbon brushes will be replaced when 1/4" is worn from their length (as compared to a new one.)
2. Installation of new carbon brushes.

a. Check brush for fit in tube. Place spring and plug on pigtail, fold back 1/2" of end of pigtail, refold that in half, leaving lead to brush coming out between the folds, then clamp terminal over the four thicknesses. Do not cut the ends of the pigtails. They are cut to exact length at the factory.

b. Use no solder on connections, as solder destroys the balance of the gyro. Brush should make a minimum of 85% contact with the commutator. This is obtained by running in brush for a few minutes, then scraping the high spots (bright spots) with a sharp straight edged tool. Run in again and recheck. CAUTION: Scrape very lightly.

c. The brush nuts should be turned down to exactly the same position as before removal. The factory adjustment is, with the nut extended, 5/16" on the stab. gyro. No change should be made in this setting to adjust the spring tension on the brushes. If the tension is not correct with this adjustment, the cause is a defective spring or worn brush.

Slip Rings
Stab.

Fig. 24

1. Clean slip rings with #400 aluminum oxide and polish with crocus cloth. Brushes may be stoned smooth.
2. See that brushes have equal tension. Bend the slip ring brushes in 5/16" from base of brush to top of bend. Brushes must be very smooth at contact points and spread slightly at slots through center of brushes.
3. Brushes must ride center of rings and not touch insulation on either side, and lie flat against the slip rings.

Isolated
Sector
Stab.

Fig. 25

1. Remove pits and burrs with #400 aluminum oxide paper, by placing the #400 aluminum oxide paper on a flat surface (stabilizer rear inspection plate) and by rubbing the isolated sector across the paper lengthwise to the sectors. Polish with crocus cloth or fine Arkansas stone, polishing or stoning parallel to the sectors.
2. Use ohmmeter to check for continuity between sectors; there should be none.
3. The contact point of the isolated sector contact brush should have a 1/32" bevel top and bottom. Bevel edges should be papallel to each other and to the insulation between sectors. The contact point must ride perfectly flat on the sectors. Do not round the point. The use of the dental mirror and loupe will detect points that are not correctly shaped. The point should oscillate a very small amount before contacting a 6-volt sector.

c. Torque Motor.

1. The torque motor is a parallel wound motor rotating at approximately 4144 r.p.m. The clutch gears rotate 110 r.p.m. plus or minus 5 r.p.m. The clutch gears rotate in opposite directions. The bronze gear rotates counter clockwise and applies a counter clock-wise torque to the ring gear. If the isolated sector contact brush contacts one of the lower segments, the clapper magnet under the brass gear is energized and the gyro is precessed back to the neutral position. If the isolated sector contact brush contacts the upper segments of the isolated sector, the clapper magnet under the steel gear is energized and the gyro is precessed to the neutral position.

1. To check the speed of the torque motor;

a. Wedge the gyro so that the isolated sector contact brush contacts a 12 volt segment.

b. With stabilizer switch "off", clutches disengaged and servo "on", torque motor should turn cardan approximately 3 R.P.M. plus or minus 1/2 R.P.M. If it does not, check circuits to clapper magnet and torque motor and check for clutch slippage.

c. Repeat the above procedure in the opposite direction.

1. The torque motor clutches slip at 32-36 lbs. minimum. With bombsight clutch set at 24 lbs., engage it with gyro dead. Hold down or up on gyro bearing cap so that stabilizer brush contacts 12 volt sector. With torque motor "on" male member of clutch should turn inside clutch collar. Make check in both directions. To increase pull of magnets, turn off one thousandth of an inch at a time from the bronze plug in the magnet clapper on which the clutch plate pinion rests. This must be done in a lathe and only if absolutely necessary. The pivot pins that hold the clappers in should be perfectly straight.

2. Free movement of the clappers is essential Adjust the torque clutch plates to minimum clearance without drag by shaping the tips of the bayonet springs. This clearance will be approximately .003". The back lash between the intermediate and precession gears can be adjusted by removing or adding paint to the torque motor frame.

CLEANING CLUTCHES (TORQUE MOTOR)

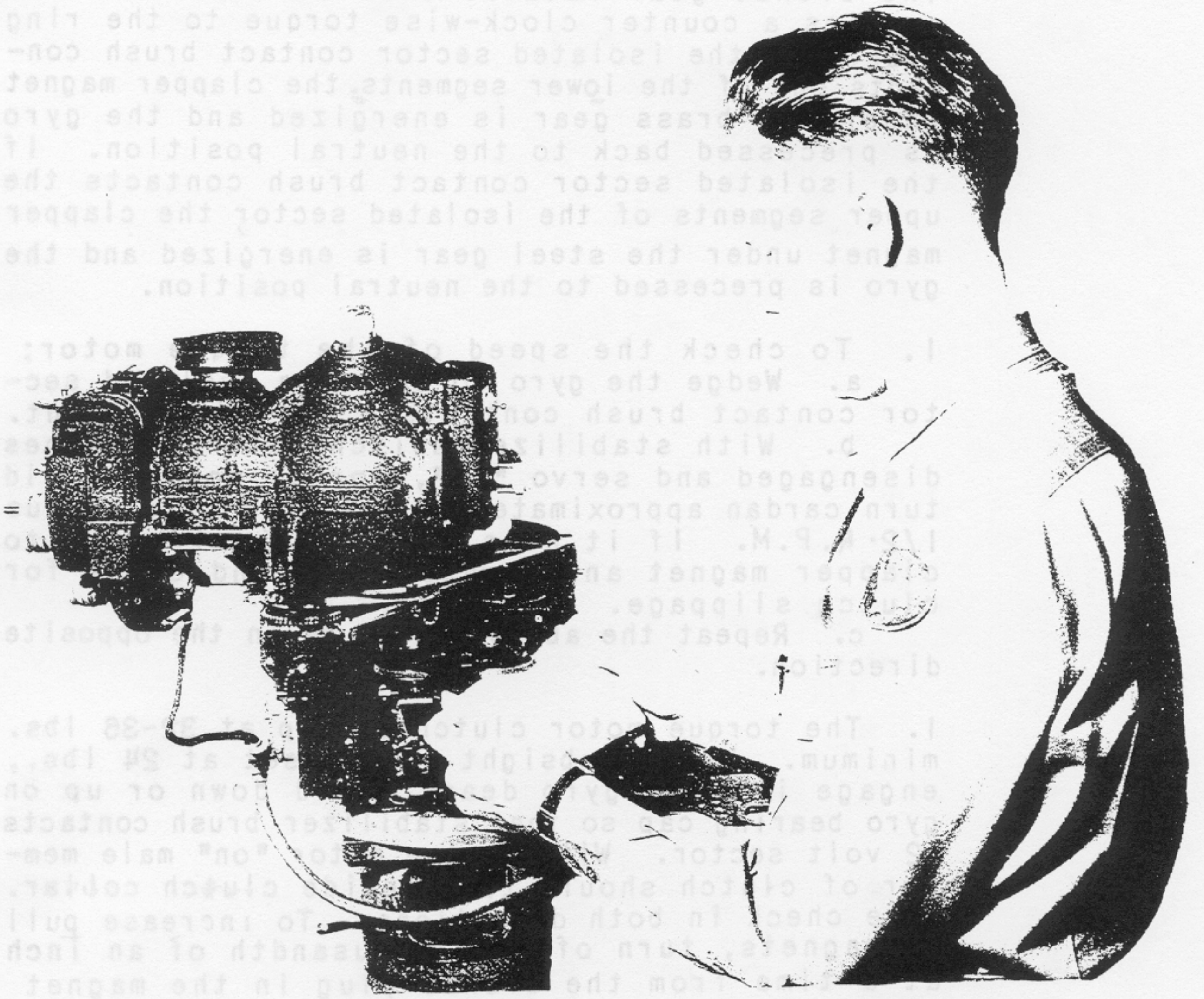


FIG. 26

3. Clean clutches with clean white cloth. Place cloth between clutch plate and cork insert, wedge gyro and turn torque motor on. Be very careful to hold cloth out of gear teeth and to keep clutch surfaces free of lint. Keep using new section of cloth until no oil or dirt appears on it.

CLEANING COMMUTATOR

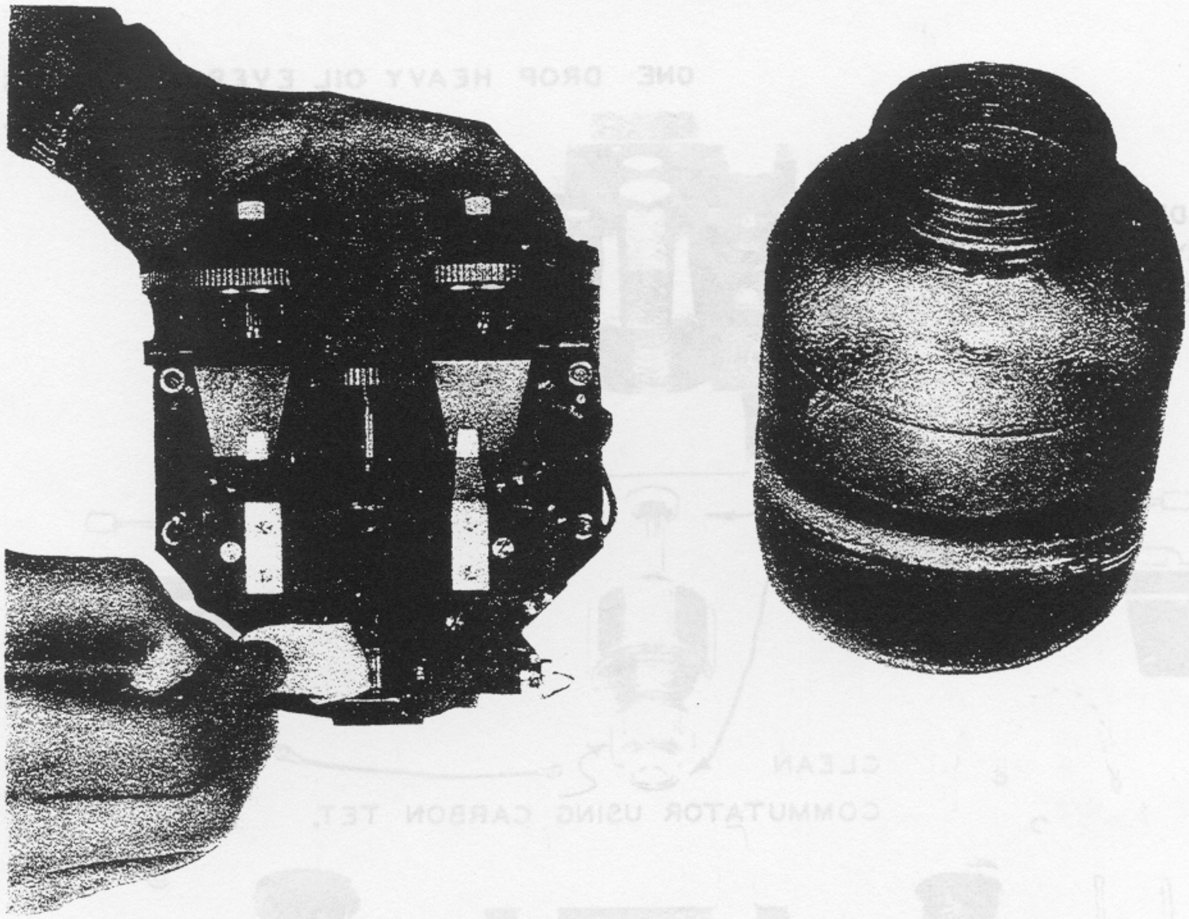


FIG. 27

Brushes

1. Clean carbon brushes with alcohol or carbon tet.
2. Brushes should make a minimum of 85% contact with the commutator. If the brush does not make 85% contact use a sharp tool to scrape the high spots on the brush. The high spots will be bright while the rest of the brush will be dull. Always "run in" brush after scraping. Then check brush and clean commutator with clean white cloth and moisten with carbon tet.
3. Replace brush exactly as it was before removal from tube.
4. The brush plug should extend 1/4" from the end of the brush tube.

TORQUE MOTOR DISASSEMBLY

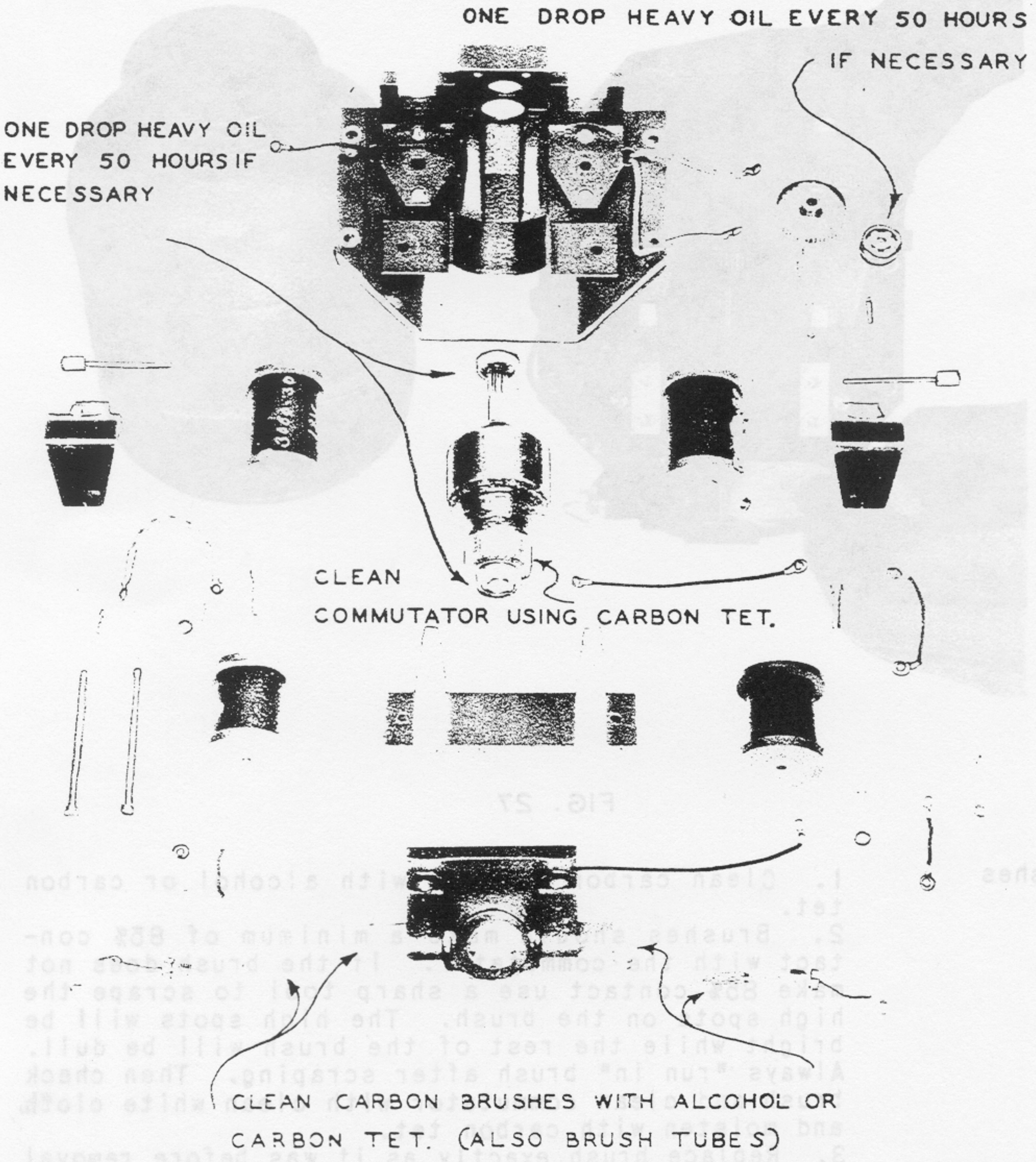
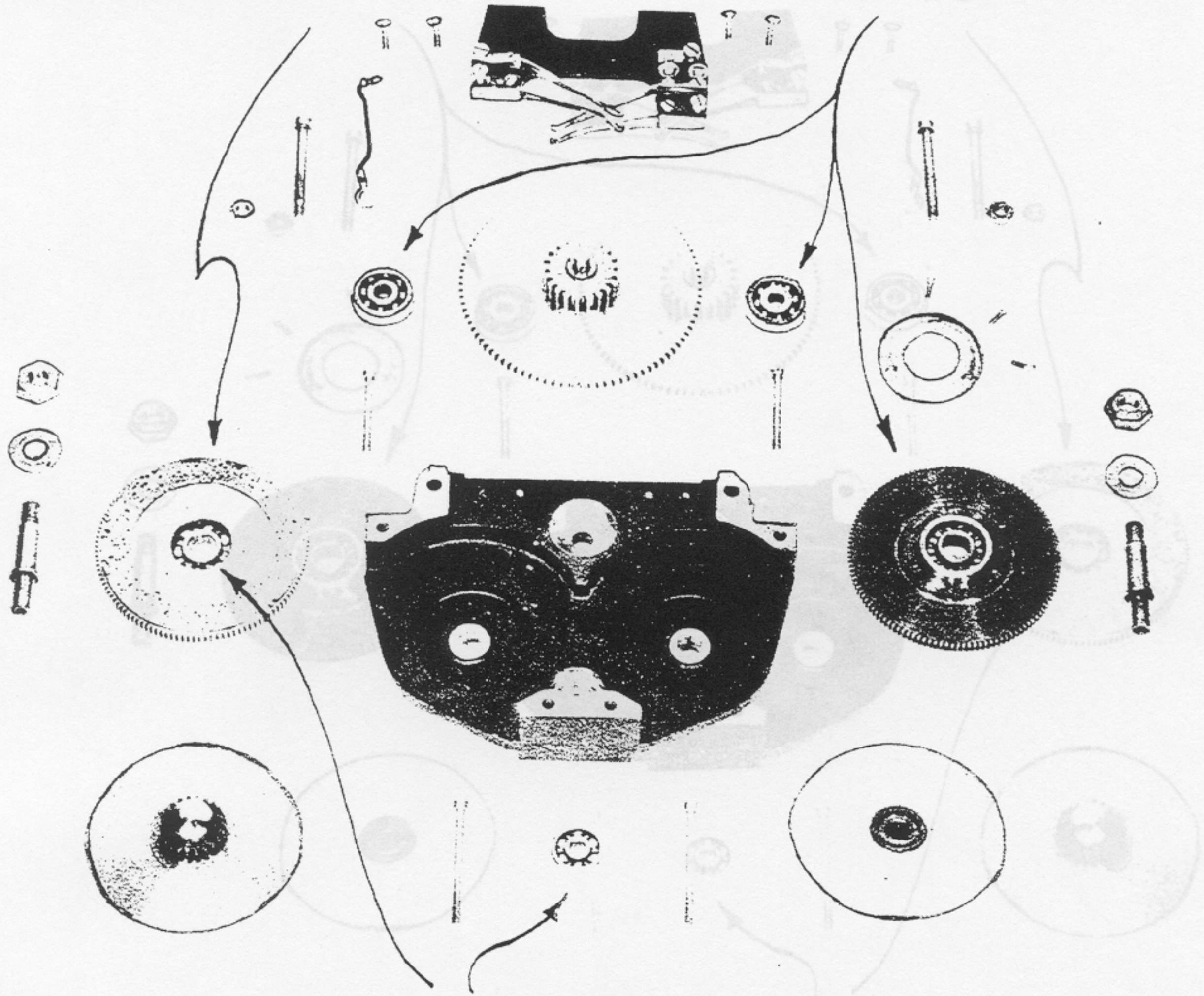

ONE DROP HEAVY OIL EVERY 50 HOURS IF NECESSARY
ONE DROP HEAVY OIL EVERY 50 HOURS IF NECESSARY
CLEAN COMMUTATOR USING CARBON TET.
CLEAN CARBON BRUSHES WITH ALCOHOL OR CARBON TET. (ALSO BRUSH TUBES)

FIG. 28

TORQUE MOTOR DISASSEMBLY



KEEP CORK SURFACES CLEAN USING CARBON TET.

EVERY 50 HOURS ONE DROP HEAVY OIL IF NECESSARY

ONE DROP HEAVY OIL EVERY 50 HOURS IF NECESSARY

FIG. 29

8. Note the amount of drift and move the stabilizer mounting bracket to compensate for the difference.
9. If the adjustment on the mounting bracket is not sufficient to allow for compensation, report to sub-depot.

TORQUE MOTOR DISASSEMBLY

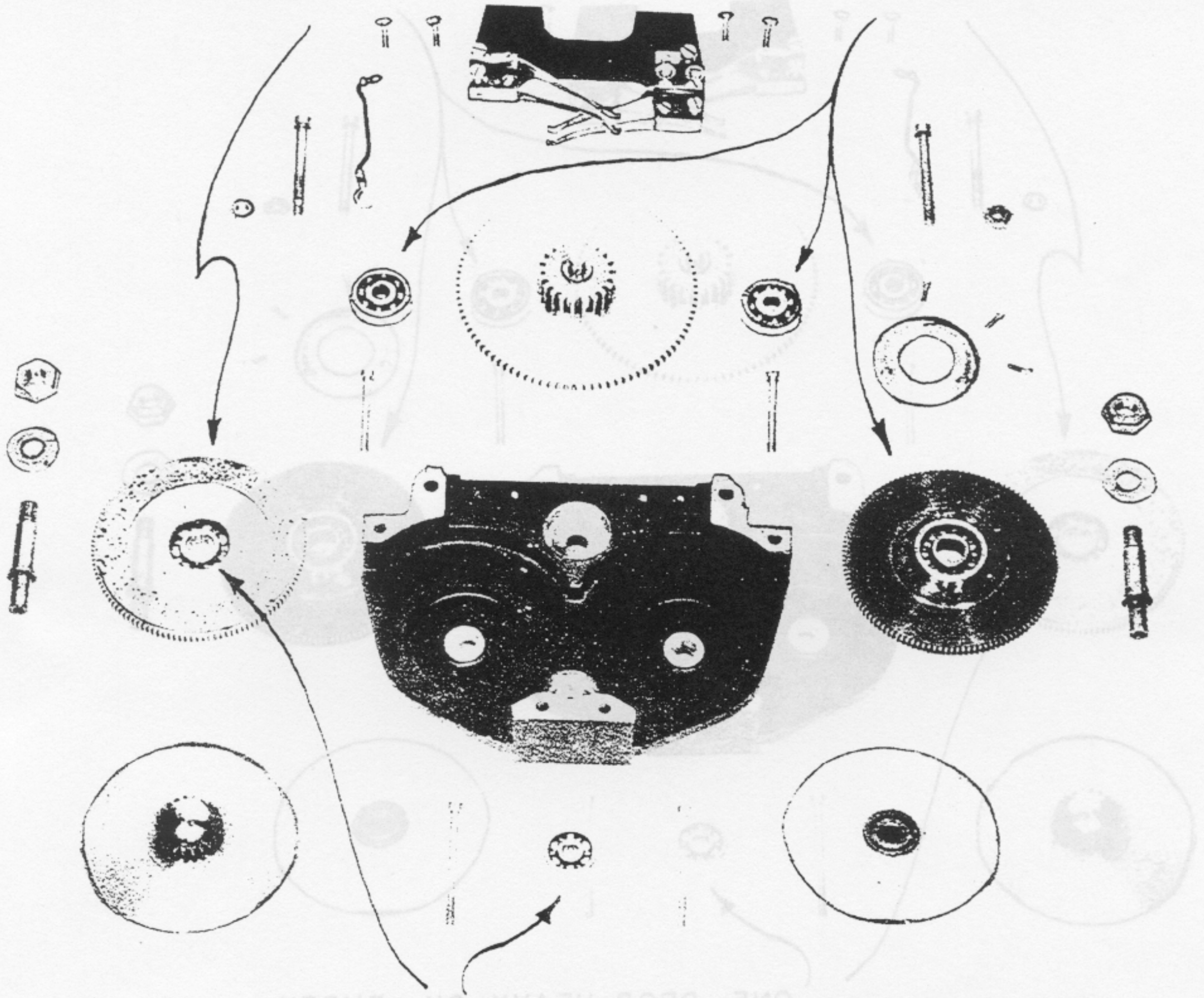
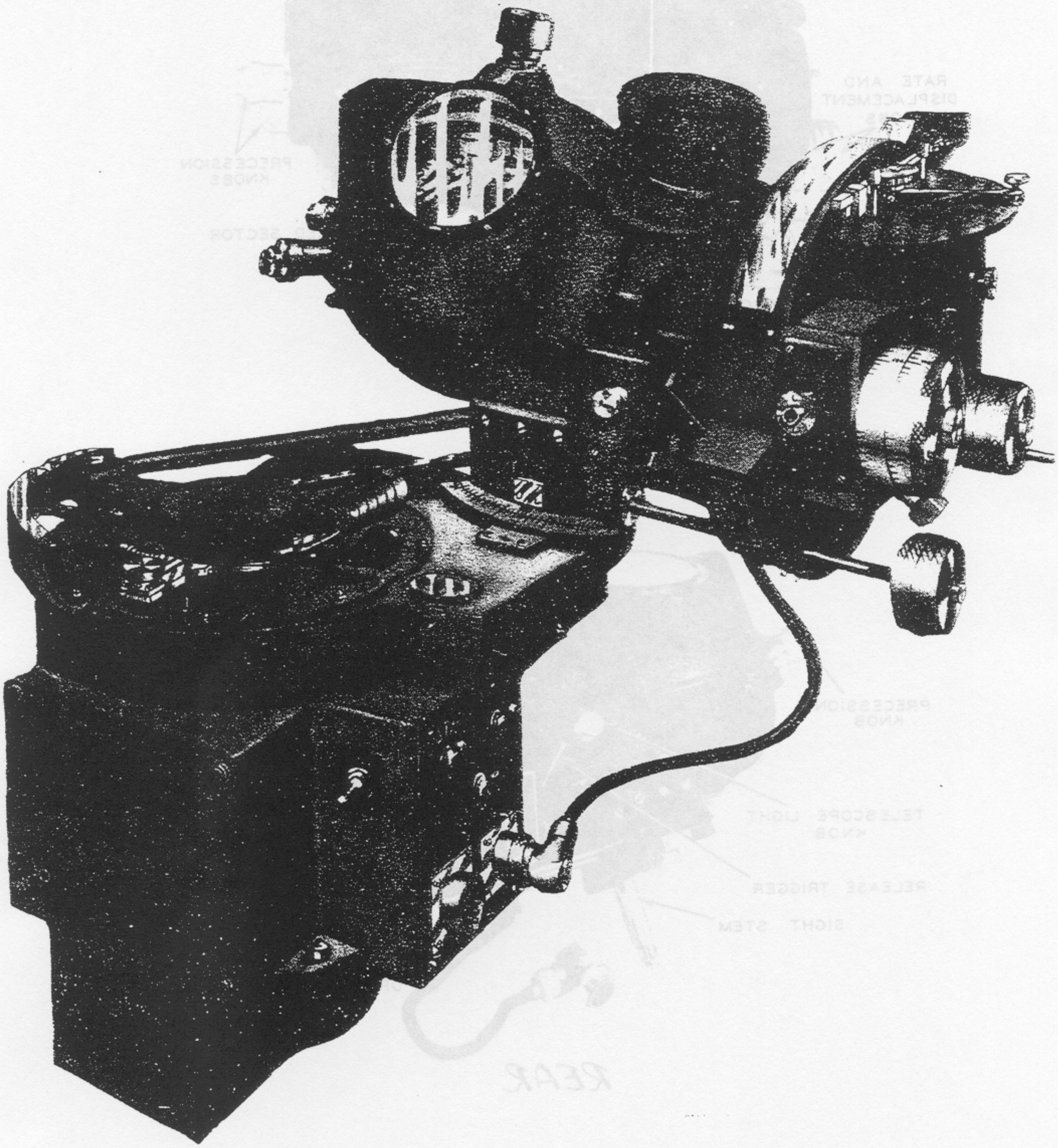


FIG. 29

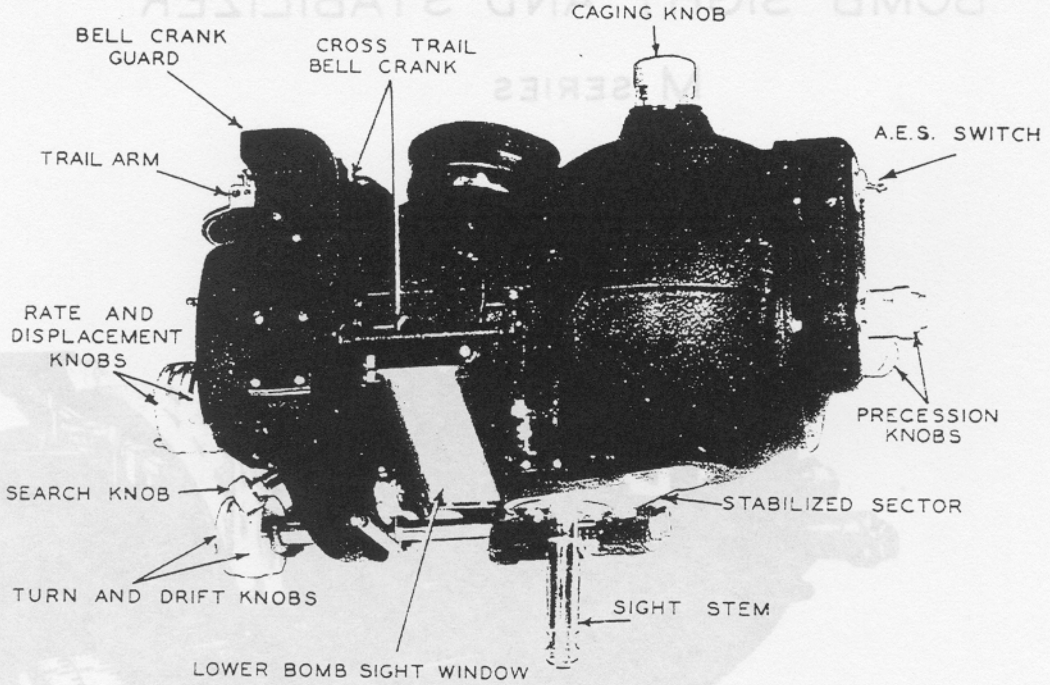
8. Note the amount of drift and move the stabilizer mounting bracket to compensate for the difference.
9. If the adjustment on the mounting bracket is not sufficient to allow for compensation, report to sub-depot.

BOMB SIGHT AND STABILIZER

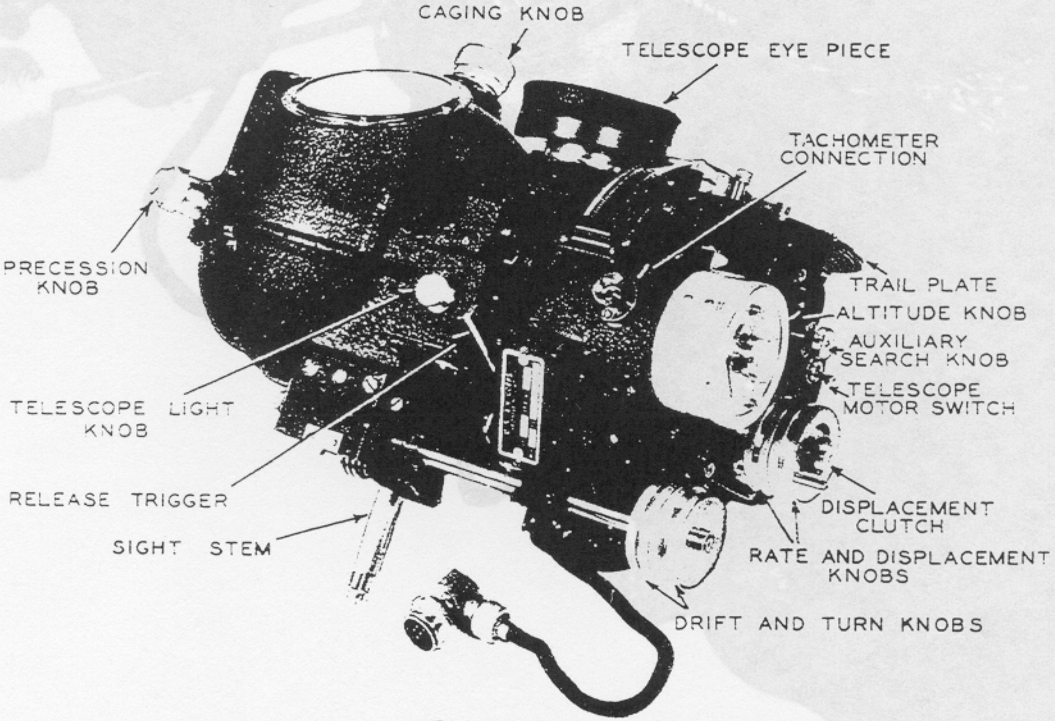
M SERIES



BOMBSIGHT



FRONT



REAR

FIG. 30

SECTION V
OPERATION AND NOMENCLATURE, SIGHT

Purpose of Sight

The purpose of the bombsight is to enable the bombardier to drop bombs with the greatest degree of accuracy. In so doing the instrument sets up or determines a line of sight which, at the instant of bomb release, will subtend actual range distance on the ground or the horizontal distance that the bomb will travel on its path through the air. The bombsight also determines the proper course of the airplane in order to maintain the necessary line of sight according to the prevailing atmospheric conditions.

General Description of Sight

N.O.P. #649
A. Type of sight

Fig. 30

The bombsight is a stabilized instrument. The cross hairs of the telescope are mechanically stabilized, and are stabilized in the vertical by the vertical gyro and about the vertical or in the horizontal plane by the directional gyro. The Norden sight is a synchronizing mechanism. The term, synchronizing, means that the bombardier can, by properly adjusting the course, rate and displacement knobs, cause the intersection of the cross hairs to remain on the point of aim or target by causing the mirror, in the M-6 and the telescope in the M-3, to turn about its lateral axis at the proper speed, that is, a speed proportional to ground speed. When the sight is properly calibrated and is correctly synchronized, it will accurately solve the bombing problem.

B. Identification of Sight M-3 (Exterior)

In considering and explaining the exterior of the sight, we must bear in mind that right and left, front and rear, are determined from the bombardier's position. The rate end of the sight is to the bombardier's right and the vertical gyro to his left. The rear of the sight is toward the bombardier and the front away from him. The Navy reverses these positions.

On the left end of the sight are the precession or leveling knobs. These knobs give the bombardier control over the vertical gyro so that he may level it whenever he desires. The center knob causes the gyro to precess about its transverse axis and in the fore and aft plane. The knob to the rear of center causes the gyro to process about the fore and aft axis and in the transverse plane. It must be remembered that the gyro must be running to secure the above precessions; otherwise the gyro and cardan will move in the opposite directions. (Review laws of precession.) The case which houses the gyro and cardan is divided into two parts, the upper and lower housings. The upper housing is attached to the lower part of the case with eight (8) screws. The two (2) screws in the upper part of the left end must be removed in order to remove the upper housing.

Located in the center and rear of the lower housing is the cross trail knob which is turned to the left to set in trail. When this knob is turned an eccentric disc and stud are moved to the rear of the center of the sight stem. The purpose of this eccentric disc will be discussed later. This knob is found on the M-1, M-2, and M-3 sights only. On the upper half of the housing we have, in the center top left, the caging knob. This is a push-pull knob, and locks the gyro in a near vertical position when not actually making a bombing run. Near this knob but to the rear of the housing we find a window which allows the bombardier to see the obtics. In the case of the M-3, the telescope moves, and in the case of the M-6, it consists of a stationary eye piece. Just below this window, but on the lower half of the sight housing we find the telescope light knob. The purpose of this light is to light up the cross hairs. This is done by means of two slots, one in the case, and a matching slot in the telescope tube. The telescope light knob controls a rheostat.

The extreme right end of the sight is made up of a switch and four knobs, the altitude, rate, displacement and search knobs. At the top and jutting out from the rate end, we find a semicircular calibrated plate and a movable arm. This is the trail setting mechanism and by the arm trail is set. Just beneath this mechanism is a toggle switch which turns "on" and "off" the telescope motor. On the left side of the rate end, as we face it, is the altitude knob, which is calibrated in disc speed and altitude in feet on some units. This knob controls the speed of the telescope motor and disc. At a point just below the center of the diameter of the rate end ~~are the~~

are the rate and displacement knobs. The outer or displacement knob allows the bombardier to displace the optics independently of the rate of drive. The inner knob is the rate knob, and controls the angular speed of the optics. We will discuss these knobs more fully later. At the very bottom of the rate end is a knob which enters the rate end at an angle. This knob is called the search knob and rapidly displaces the optics. Situated within the displacement knob is a locking clutch (locked when pushed in and unlocked when pulled out.) This clutch merely engages the displacement knob. The search knob must never be used when the clutch is engaged. The rate and displacement knobs are located together so that they can both be used at one time by double gripping.

I. Sight Assemblies

A. Course Knob Assembly

Fig. 31

On the rear and lower part of the sight case is attached the course knob assembly. This assembly consists of the turn knob, the drift knob, the turn worm, the drift worm and the intermediate gears which drive the drift worm. The turn knob is fastened to the inner turn rod and carries the turn worm directly. The turn worm acts directly upon the rack of the stabilized sector.

The drift knob is fastened to the outer shaft which is connected to the drift worm through two gears. The drift worm acts directly upon the drift gear which is collared around the sight stem sleeve. The drift worm is mounted in a swivel housing which is adjustable so that proper clearance between the drift gear and drift worm may be maintained.

The assembly is fastened to the sight case with seven screws. The course knobs are used to set up the course of the airplane in relation to the line of sight. When the turn knob is rotated the turn worm will track around the rack of the stabilized sector which is stabilized by the bombsight clutch.

The drift worm will drag the drift gear as the sight tracks about the rack of the stabilized sector. When the drift gear turns the stabilized brush is displaced and a reading is registered on the PDI. The PDI tells the pilot which way to turn the plane to bring it back to straight flight.

COURSE KNOB ASSEMBLY

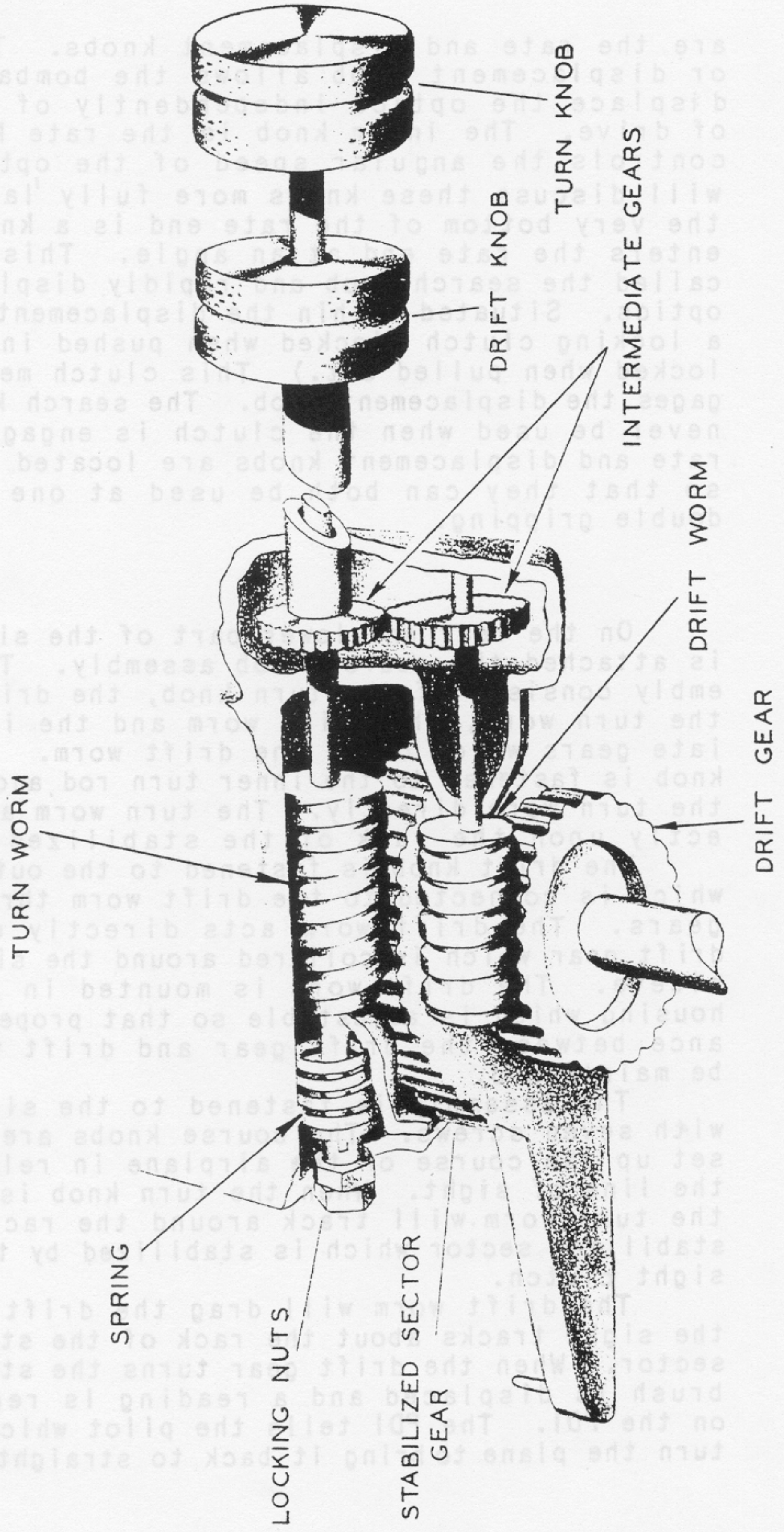


FIG. 31

If the drift knob is turned the drift worm rotates the drift gear which will displace the stabilized brush giving a reading on the PDI.

When both knobs are rotated at once it is called double gripping. To set up the course properly the knobs may be double gripped. It must be remembered that the auto-pilot clutch is a slip connection between the directional gyro and the stabilized PDI brush, and that unless the auto-pilot clutch is dis-engaged the PDI brush will be displaced when the course knobs are rotated. With the bombsight clutch engaged and the auto-pilot clutch disengaged, the PDI brush will be displaced and the sight will rotate in azimuth as the course knobs are double gripped.

Over-correction factor is the amount the airplane is turned more than the line of sight while double gripping. The over-correction factor on the M-3 is 5 1/4. On, later units it is 6 1/4. The sight turns 1° R or L and the airplane turns 6 1/4° on the M-3 and 7 1/4° on the M-6.

B. Stabilized Sector

Fig. 31

The stabilized sector is the gear connection between the sight and the sight clutch connecting rod. The stabilized sector is a part of the bombsight. Beigg so, when it is stabilized in azimuth (it is stabilized by the stabilizer gyro through the sight clutch connecting rod), the entire bombsight case is also stabilized in azimuth.

C. Altitude Knob Assembly

N.O.P. #649

The altitude knob assembly is composed of an outer knob calibrated in revolutions of disc speed and in feet of altitude on some units. This outer knob is removable. There are two altitude springs and two cases. The outer spring supplies the ten-only when high disc speeds are necessary, as in low altitude bombing; the inner spring supplies the tension for low disc speed used in high altitude bombing, but its tension is always being employed, even for high disc speeds in which case the outer spring commences to add its tension to that of the inner spring. These springs translate their torque through the altitude shaft to the breaker arm. This torque keeps the contact points closed until the tension of the altitude springs is overcome by the telescope motor governor. The

ALTITUDE KNOB ASSEMBLY

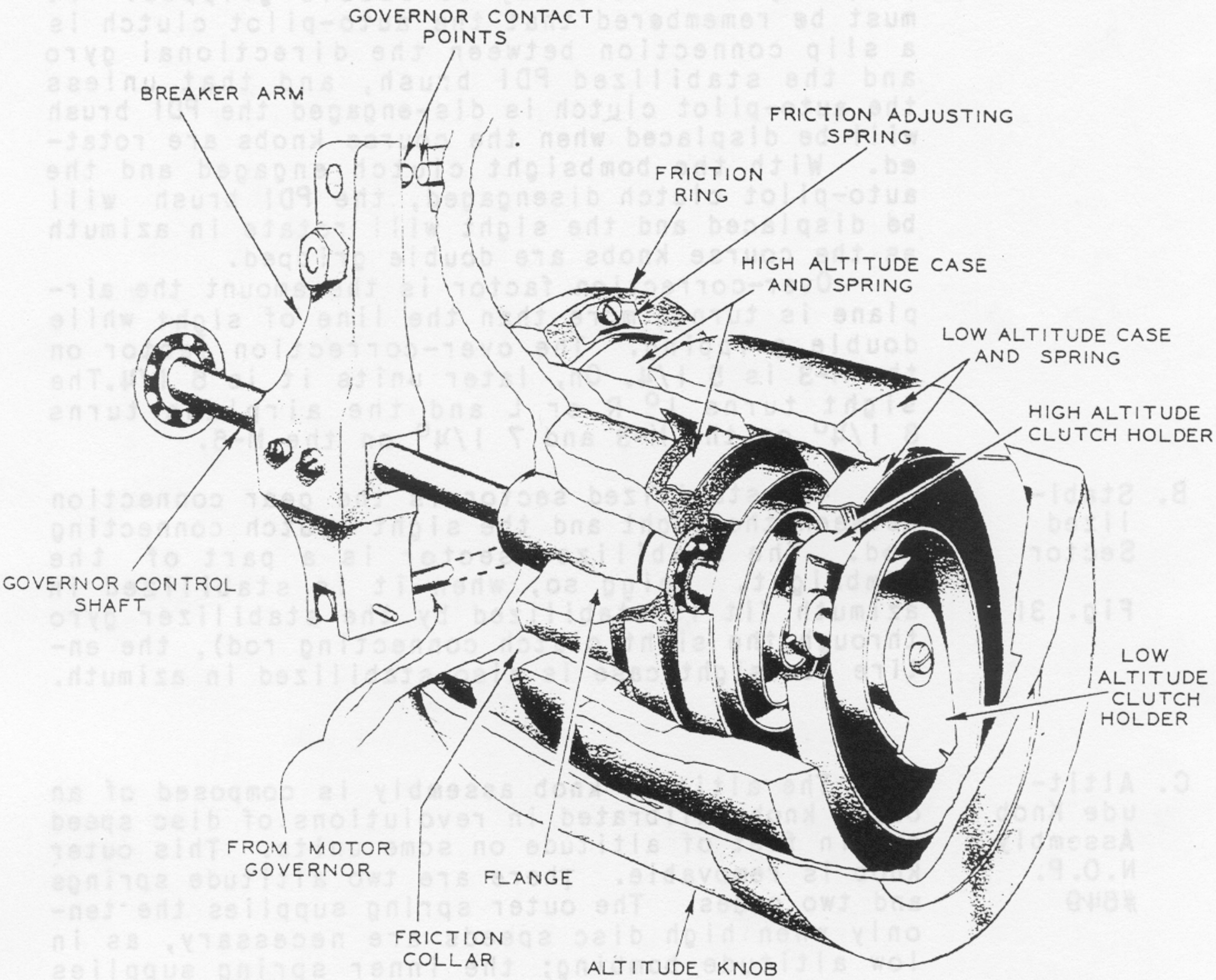

GOVERNOR CONTACT POINTS
BREAKER ARM
FRICTION ADJUSTING SPRING
FRICTION RING
HIGH ALTITUDE CASE AND SPRING
LOW ALTITUDE CASE AND SPRING
HIGH ALTITUDE CLUTCH HOLDER
GOVERNOR CONTROL SHAFT
LOW ALTITUDE CLUTCH HOLDER
FROM MOTOR GOVERNOR
FLANGE
FRICTION COLLAR
ALTITUDE KNOB

FIG. 32

inner altitude spring case fits over a friction collar. The inner altitude spring case is held in place on the friction collar by three adjustable set screws which must be loosened to rotate the case on the collar. The outer case fits over the inner case and is held in place with three adjustable set screws. In order to maintain the spring tension on the springs a fiber friction ring frictionally engages the flange of the friction collar. The tension of the friction ring is regulated by two leaf springs called friction adjusting springs, one on the top and one on the bottom of the friction ring. The tension of the leaf springs must be sufficient to hold the altitude knob at any desired position. Keyed to the altitude shaft is the high altitude clutch holder against which the low altitude clutch holder contacts as the outer case is rotated clockwise. A continued rotation of the outer case in a clockwise direction increases the tension of the outer altitude spring. The necessary screws and bearings complete the assembly.

I. Adjustment of the Altitude Knob

Fig. 32

Do not remove outer spring collar in disassembly or maintenance. Turn on the telescope motor and take minimum and maximum tachometer readings. The minimum disc speed on the M-3 is 117 and maximum disc speed is 417. On the M-6 Series and up the disc speed is 101 to 593. A gear change arrangement provides for a disc speed of 101 to 246 plus or minus 1/2 when the shift is on low and for a disc speed of 246 plus or minus 1/2 to 593 when the shift is on high position.

If the altitude knob is out of adjustment proceed as follows. Always adjust the inner altitude spring tension first. If the minimum speed is too slow turn the inner case to maximum stop, loosen the three set screws and rotate the case clockwise. Tighten screws, rotate to minimum stop and check speed. Repeat this until the correct speed is attained. If the minimum speed is too fast, rotate inner case to minimum stop, loosen set screws and rotate case counter clockwise until minimum speed is obtained. Tighten all three set screws; then proceed to adjust the outer spring case. Rotate the outer case clockwise to increase speed and counter-clockwise to decrease speed. Be sure the set screws are loosened before attempting to turn the case. Also check the mini-

RATE END CUTAWAY

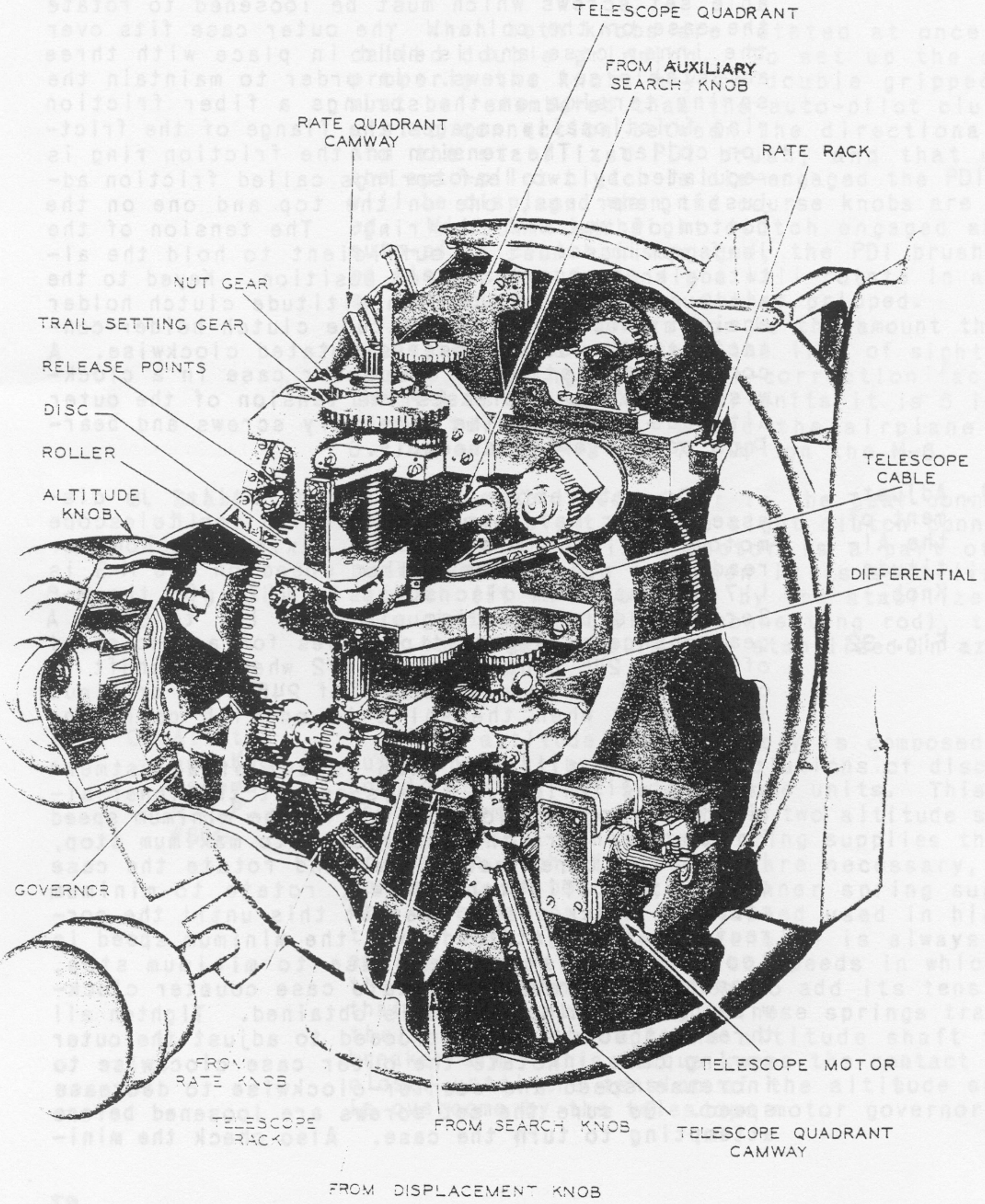


FIG. 33

mum speed after adjusting for high speed and also be sure that the brake springs exert enough pressure against the brake ring to hold the altitude knob in any position.

The altitude knob is important in the solution of the bombing problem because the springs control the speed of the telescope motor.

We are now ready to consider the interior of the sight. First we remove the five screws holding the rate end and remove the rate end. The rate end, motor half, houses the telescope motor assembly, displacement and rate knob assembly, search knob and disc assembly.

D. Telescope Motor Assembly

Fig. 33

The telescope motor assembly consists of the following. A parallel wound constant speed motor, field coils, carbon brushes, governor, breaker arm and necessary bearings, pin screws and wiring.

The telescope motor drives and controls the speed of the disc. The speed of the motor is controlled by having a set of breaker points wired in series with the armature. The breaker points are kept closed by the tension of the altitude springs until the governor overcomes that tension.

As the motor speeds up the arms of the governor tend to become parallel, thereby pulling the connecting links and collar toward the center of pivot of the governor and at the same time moving the breaker arm with them. The breaker arm is attached to the altitude shaft. As the breaker arm is pulled toward the governor the breaker arm pivots the altitude shaft, overcoming the tension of the altitude springs, and breaks the contact between the points. The circuit to the telescope motor is broken. The motor slows down; the pull of the governor becomes less than the tension of the altidude springs and the breaker points are closed and the circuit is again completed. This action is so rapid that the speed of the telescope motor remains constant.

E. Rate and Displacement Knob Assembly

This assembly consists of rate knob (inner knob), displacement knob, displacement clutch engaging knob and shaft, displacement shaft, bevel pinion and intermediate gears.

The displacement knob enables the bombardier to move the optics independently of the rate of drive.

RATE AND DISPLACEMENT MECHANISM

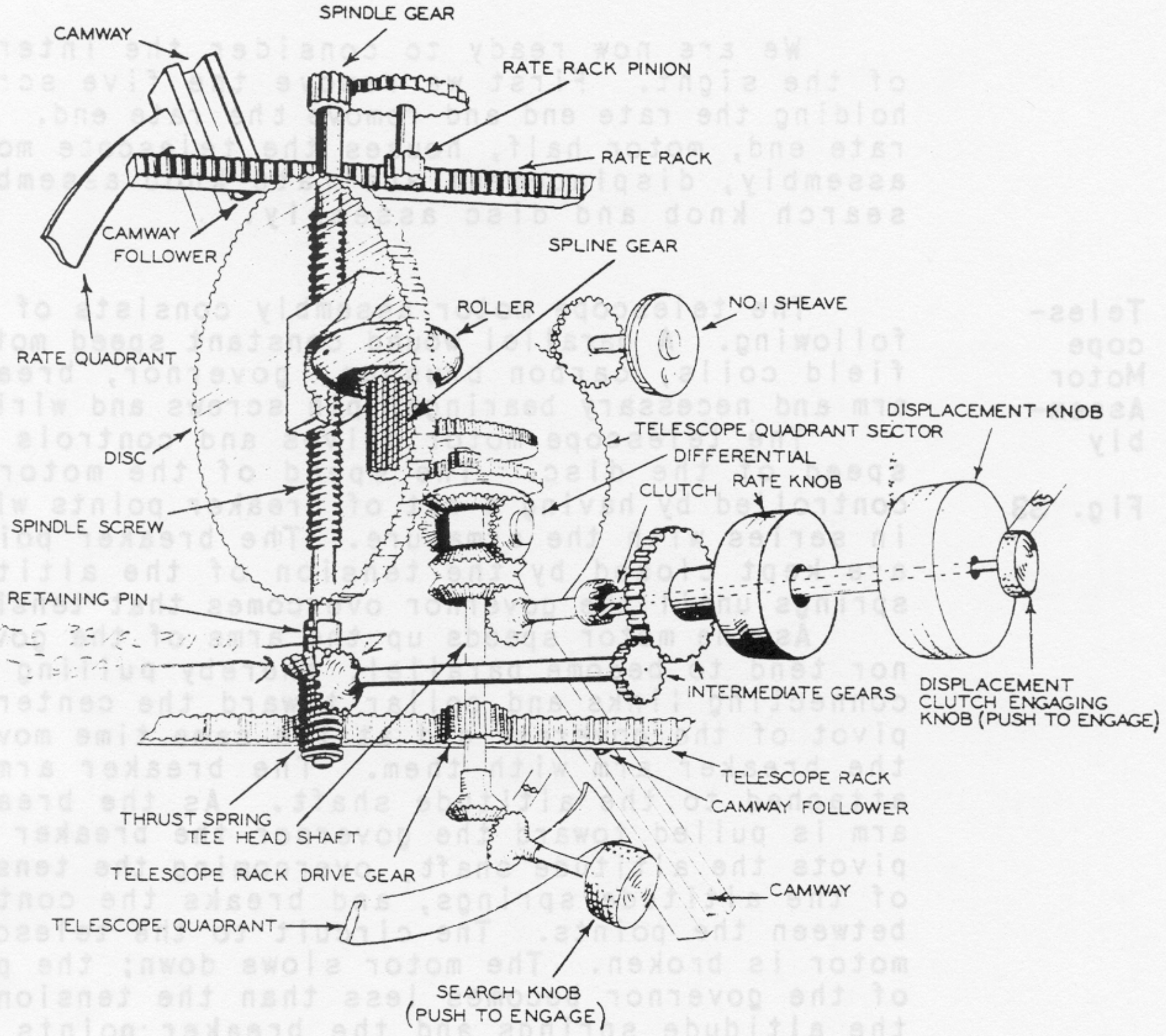


FIG. 34

Fig. 34

The rate knob enables the bombardier to set up the correct rate of drive so that he can synchronize by positioning the roller on the disc.

F. Disc Assembly

The disc assembly consists of the disc, tachometer shaft, tachometer shaft springs, bearing blocks, bearings and screws, inspection plate and tachometer connection.

Fig. 34

The disc drives the roller which translates the drive to the rate and telescope drive mechanisms. The tachometer shaft spring supplies the tension which holds the disc against the roller; the tachometer shaft and connection transmit the the speed of the disc to the tachometer when the tachometer is applied.

G. Search Knob Assembly

The search knob, shaft and bevel pinion are parts of the search knob assembly. It is used to displace the optics quickly and independently of the displacement knob. The search knob must not be used without disengaging the displacement clutch because of the danger of shearing the displacement clutch pin.

H. Trail Assembly
N.O.P. #649

Fig. 30 and 34

This consists of the following: trail plate (see rear view of sight), trail arm, trail setting gear, nut gear, thrust washer and spindle screw. When the trail arm is rotated toward maximum trail the trail setting gear rotates the nut gear which moves up on the threaded upper spindle bearing and against the thrust washer which carries the spindle screw in translation against the tension of the spindle spring. The roller is thus moved up from the disc center a distance proportional to trail without affecting the rate mechanism.

The spindle spring forces the spindle screw in translation downward as the trail arm is rotated toward minimum.

I. Rate Assembly

Fig. 34

The rate assembly consists of the rate knob intermediate gears, rate bevel pinion, rate bevel gear, rate bevel gear retaining pin, thrust spring, spindle screw, roller and roller carriage, spindle gear, rate drive gear, rate rack pinion, rate rack, rate rack cam follower or stud, rate quadrant camway, rate index, automatic release points, ground speed drum and ground speed scale.

This synchronous assembly sets up the rate of drive necessary to synchronize on the target.

It is assumed that the sight is correctly calibrated. The student must remember that the rate quadrant at the start of any bombing operation is at zero or approximately zero. The student must also remember that the rate quadrant moves from zero to maximum value of the tangent function, and that the telescope quadrant moves from maximum sighting angle toward zero sighting angle. With this in mind we will set up the rate of drive as follows. When the rate knob is rotated clockwise the intermediate gears drive the rate bevel pinion which drives the rate bevel gear is attached to the spindle screw with a retaining pin. As the rate bevel gear rotates the spindle screw is rotated. The spindle screw moves up and down only as the trail arm is rotated. The roller carriage is threaded and as the spindle screw rotates the carriage moves up or down on the spindle screw. As the rate knob is rotated clockwise the roller carriage moves upward on the spindle screw thereby moving the roller up from the center of the disc. The spindle screw turns the spindle gear,thus driving the rate drive gear, rate rack drive pinion, the rate rack and the ground speed drum drive gear. The rate rack is driven in translation a distance proportional to actual range if trail is set in and proportional to whole range if no trail is set in. At time of synchronization the rate rack cam follower or stud, riding in the rate quadrant camway, translates the rate quadrant and angular distance proportional to the whole range angle, if trail has not been set in, or actual range angle if trail has been set in.

When we synchronize, the roller is a distance proportional to whole range from the center of the disc. The telescope rack is driven proportional to ground speed. The telescope is driven at an angular speed equal to ground speed.

Four things are accomplished when the rate knob is rotated:

1. The roller is positioned on the disc.
2. The automatic release points are positioned.
3. Ground speed in knots is indicated by ground peed dial.
4. The actual range angle--in terms of tan function--is indicated by the rate indicator.

J. Automatic Release Mechanism

This mechanism in the sight is so set up that a pair of contact points (knife type switch in the M-3) will make contact when the trigger is pulled up; when the rate and telescope quadrants indicator's coincide. The points are located on the rate quadrant. The movable point has an extension automatic release finger which rides on the telescope quadrant. When the trigger is pulled up, a sliding bar that covers the telescope quadrant is moved out of the way. This allows the automatic release finger to fall into a cut out portion of the telescope quadrant and permits the release points to close. When the points contact, the current is transmitted to the bomb release mechanism located in the bombracks.

K. Telescope Quadrant Drive Assembly

Fig. 34

This assembly includes the following: displacement knob, displacement clutch engaging knob, displacement clutch bevel pinion, search knob, search knob bevel pinion, search knob bevel gear, telescope rack drive gear, telescope rack, tee head shaft, tee head telescope drive differential gears (upper traction gear, idler gears, lower traction gear), intermediate gears, roller carriage, roller, roller spline gear, telescope quadrant, camway, cam follower or stud, and telescope quadrant index.

The telescope motor drives the disc which drives the roller. The roller spline gear drives the intermediate gears which drive the upper traction gear. As the upper traction gear turns the idler gears will track around the lower traction gear provided the displacement clutch is engaged. If the displacement clutch is not engaged the pinion gears will rotate the lower traction gear. With the displacement clutch engagedthe pinion gears will track around the lower traction gear and in so doing rotate the tee head shaft which will rotate the telescope quadrant rack drive pinion and drive the telescope rack in translation. The cam follower, or stud on the rack, riding in the camway causes the telescope quadrant to move in translation as the rack is driven. The cam follower, riding in the camway, gives a constant acceleration to the telescope quadrant because as the quadrant moves toward minimum the radius of angular movement of the quadrant becomes shorter and shorter.

The displacement knob enables the bombardier to displace the optics faster or slower than the rate of drive and independently of the rate of drive. If the displacement knob is rotated clockwise the rate of drive is increased and the lower traction gear moves in the same direction as the upper traction gear.

If a very rapid displacement of the optics is required, disengage the displacement clutch and engage the search knob bevel pinion with the search knob bevel gear. Rotate the search knob. The bevel search knob gear is rotated and will rotate the tee head shaft and telescope rack drive pinion causing the rack to be displaced.

The telescope is driven through a system of gears, five sheaves and a cable. The cable operating sheave, or number one sheave gear, is in mesh with the telescope quadrant sector gear. As the quadrant rotates the cable operating sheave is rotated in the opposite direction. (The sheave is free to turn on the gear shaft but is held stationary by a clamp and eccentric screw.) The clamp fastens about the gear shaft and the eccentric screw fits into a slot on the sheave. A one-half turn of the eccentric screw in either direction will give adjustment on the cable without reinstalling. This is approximately 1 degree.

The number two sheave is located to the right of the cardan gudgeon bearing in the rate end. The number three sheave is mounted to the cardan on the left side of the cardan bearing. The number four sheave is mounted in the cardan, and the telescope cradle gudgeon pin is milled and drilled to permit passage of the cable over the sheave and through the gudgeon bearing to the number five sheave which is mounted on the telescope cradle. The number five sheave is pinned to a gear shaft. The gear is in mesh with the telescope sector gear.

The number one sheave is the cable operating sheave. An extra flexible nine-strand bronze cable transmits the drive to the telescope.

The telescope return spring supplies a tension to the telescope about its transverse axis and maintains a tension on the cable and will return the telescope toward maximum. If it were not for this tension there would be no way of returning the telescope to maximum.

I. Installation of Telescope Cable

M-3

1. Set telescope at maximum sighting angle and remove old cable from 1, 2, 3, and 4 sheaves. Then remove #5 sheave and remove the cable from it. Caution: do not let the telescope fly back against the stop.

2. Thread cable through lead hole in #5 sheave and form an incomplete right hand loop in the end of the cable.

3. Place loop around farther anchor screw, and turn screw down enough to hold cable. Caution: always keep cable away from screw threads.

4. Take up slack in cable and tighten other anchor screw snugly. Tighten first anchor screw.

5. Thread cable around #4 sheave and install #5 sheave with telescope at minimum sighting angle.

6. Replace taper pin. With telescope at minimum sighting angle the lead hole in to sheave should be just to the rear of vertical and no cable wound on the sheave. Let telescope return to maximum sighting angle as cable winds on #5 sheave.

7. Thread cable around #4, 3 and 2 sheaves.

8. Check #1 sheave with telescope at 60° sighting angle. Eccentric clamp should be approximately vertical with the eccentric screw slot horizontal.

9. Set telescope quadrant at 40°.

10. Thread cable partially around #1 sheave and through the lead hole. Pull telescope to first mark on coincidence scale and fasten cable to #1 sheave.

11. Check to see that cable pulls tangent to #5 sheave and does not double wind on #1 sheave at minimum sighting angle. Also check to see that cable does not double wind on #5 sheave at maximum sighting angle and comes from #1 sheave on the tangent.

L. Telescope and Cradle Assembly

M-3

This assembly consists of the telescope, telescope return spring, telescope sector gear, telescope cradle, telescope cradle gudgeon (working in ball bearings), telescope coincident scale, the number five sheave and gear shaft.

This entire assembly tilts in a transverse direction left or right about the fore and aft gudgeons working in ball bearings and independently of the vertical gyro. The entire assembly tilts fore and aft if the cardan tilts fore and aft. The entire assembly is stabilized fore and aft by the

CROSS TRAIL MECHANISM

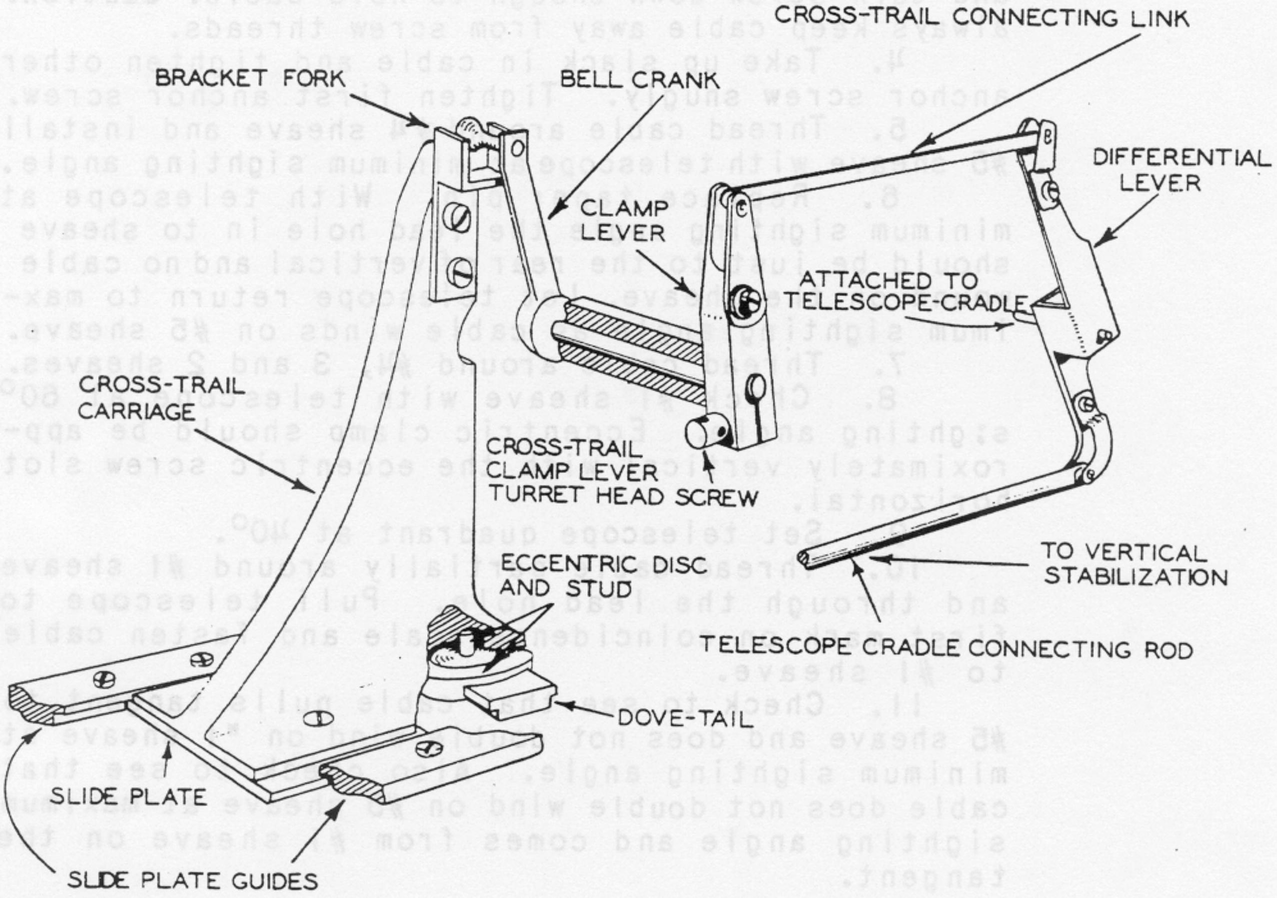

CROSS-TRAIL CONNECTING LINK
BRACKET FORK
BELL CRANK
DIFFERENTIAL LEVER
CLAMP LEVER
ATTACHED TO TELESCOPE-CRADLE
CROSS-TRAIL CARRIAGE
CROSS-TRAIL CLAMP LEVER TURRET HEAD SCREW
ECCENTRIC DISC AND STUD
TO VERTICAL STABILIZATION
TELESCOPE CRADLE CONNECTING ROD
DOVE-TAIL
SLIDE PLATE
SLIDE PLATE GUIDES

FIG. 35

cardan through the telescope gudgeon bearing and is stabilized transversely by the cradle connecting rod from the gyro casing. This connecting rod keeps the cradle always parallel to the gyro axis except as modified by the cross trail correction.

The optical system consists of a one-piece-refracting telescope of 1.5 power. This telescope requires no maintenance in the field and if anything goes wrong with it it must be returned to the depot for repairs.

M. Cradle Differential Lever

Fig. 35

Mounted on the rear of the cradle is the cradle differential lever, to which are connected two connecting rods, the cradle connecting rod (gyro connecting rod) from the gyro casing and the cross trail connecting rod (C. T. link) from cradle differential lever to the cross trail clamp lever. The cradle connecting rod tends to maintain the cradle vertical axis parallel to the gyro vertical axis in a transverse direction. The cross trail connecting rod tilts the cradle vertical axis transversely with respect to the vertical gyro as required by the amount of cross trail correction.

N. Cross Trail Mechanism

Fig. 35

The cross trail mechanism of the M-3 consists of the following: Cross trail knob, yoke, eccentric disc, eccentric stud, sight stem, dove tail, cross trail carriage, cross trail clamp lever, cross trail clamp lever turret head screw, cross trail connecting rod, cradle differential lever, telescope and telescope cradle.

The purpose of the cross trail mechanism is to tilt the telescope through an angle that will subtend cross trail distance on the ground.

When the cross trail knob is rotated counterclockwise the yoke moves the eccentric disc back from the center of the dove tail a distance proportional to trail. The dove tail is a part of the sight stem. The eccentric disc fits over the dove tail and slides fore and aft on it. The dove tail must always be parallel to the fore and aft axis of the stabilizer and the stabilizer must be parallel to the fore and aft axis of the airplane. When the eccentric disc moves aft, the eccentric stud, riding in the slot of the cross trail carriage, will move the cross trail carriage in translation in a transverse direction either to the right or left. Any transverse movement of the cross trail carriage will tilt the telescope. If the cross trail carriage moves to the right the bottom of the telescope moves to the right. If the cross trail carriage moves to the left the bottom of the telescope moves to the left. Thus if the dove tail were not parallel to the fore and aft axis of the stabilizer you would have an incorrect tilt of the telescope which would result in a delection error.

In bombing, under any condition, the bomb will always trail directly astern of the airplane. With no wind the collision course and the ground track coincide. This means that if the bombardier has correctly subtracted trail along the collision course and if he has properly synchronized on the target, the bomb will hit its objective.

If a cross wind condition exists, the collision course and the ground track no longer coincide. If the airplane flew directly over the target, the bomb would fall down wind of the objective; also it would be impossible to keep the cross hairs on the target because the plane would drift down wind. It, therefore, becomes necessary to crab the plane into the wind and thereby move the plane's ground track upwind of the collision course so that the bomb, trailing directly astern of the plane, will hit the objective. The distance the plane must fly upwind of the target is cross trail distance which is equal to the sine of the drift angle times trail in feet.

The drift angle is automatically set up by the bombsight under these conditions and is read from the drift scale on the stabilizer. The correct drift angle has been established, under cross wind conditions, when the fore and aft cross hair remains on the target.

The sight stem is inserted in the sight stem sleeve and is locked in position relative to the stabilizer with a locking nut in the M-3 and a locking pin in the M-6. As the plane is crabbed into the wind and the stabilizer turns under the sight and pivots the sight stem and dovetail. With the eccentric disc back of center, when the sight stem is pivoted, the eccentric stud moves through an arc and in so doing carries the crosstrail carriage in translation. The telescope is tilted through an angle that will subtend cross trail distance on the ground. The telescope is tilted independently of the vertical gyro. This is accomplished as follows: when the airplane tilts transversely, the gyro remains vertical and holds the cradle parallel to the gyro axis by the cradle connecting rod. If there is no change in position of the cross trail carriage the cross trail connecting rod stands fast and rotation of the cradle is about the cradle end of the cross trail connecting rod.

When the cross trail connecting rod acts (assuming the plane is not tilted transversely), the cradle differential lever pivots about the cradle end of the cradle connecting rod, and the resulting motion of the cradle differential lever pivot pin tilts the cradle.

On the M-3 the minimum amount of trail that can be set in on the cross trail knob is 23 mils. The maximum amount of trail is about 70 mils.

We have stated that if the drift is correct the bomb, when released, will hit its objective. This is slightly in error because when the optics tilt a slight error causing an overshot occurs. The amount of this error is known as Range Component of Cross Trail. The formula for Range Component of Cross Trail is trail times 1 minus the cosine of the drift angle--$T(-\text{Cos}\ \theta)$.

O. Bombsight Gyro

The bombsight gyro assembly consists of a case which is of two parts (held together with screws), gyro caging pin, leveling bubble tubes, fore and aft and transverse gyro balance weights, two carbon brushes, armature, field, two rotor ball bearings, and rotor.

The bombsight gyro rotor is an inverted cup-shaped wheel driven clockwise at about 7800 r.p. m. by direct current. The gyro spins on an axis, which, for the correct solution of the bombing problem must be vertical. Around the top and lower edge of the rotor are 10 screws. These screws are balance screws and are never removed except when balancing the gyro. Inside the wheel and bolted to it is the armature of the motor which drives it. The entire wheel or rotor is enclosed in a gyro casing. The upper part of the case carries the gyro caging pin, the upper rotor bearing, the fore and aft and transverse leveling bubble tubes and the fore and aft and transverse gyro balance weights. The lower half of the gyro casing carries, on its inside, the field coils, which fit between the gyro rotor and motor armature, and lower rotor bearing. Extending through the lower casing and at right angles to the commutator are the brush tubes which hold the carbon brushes. Attached to the bottom of the casing are

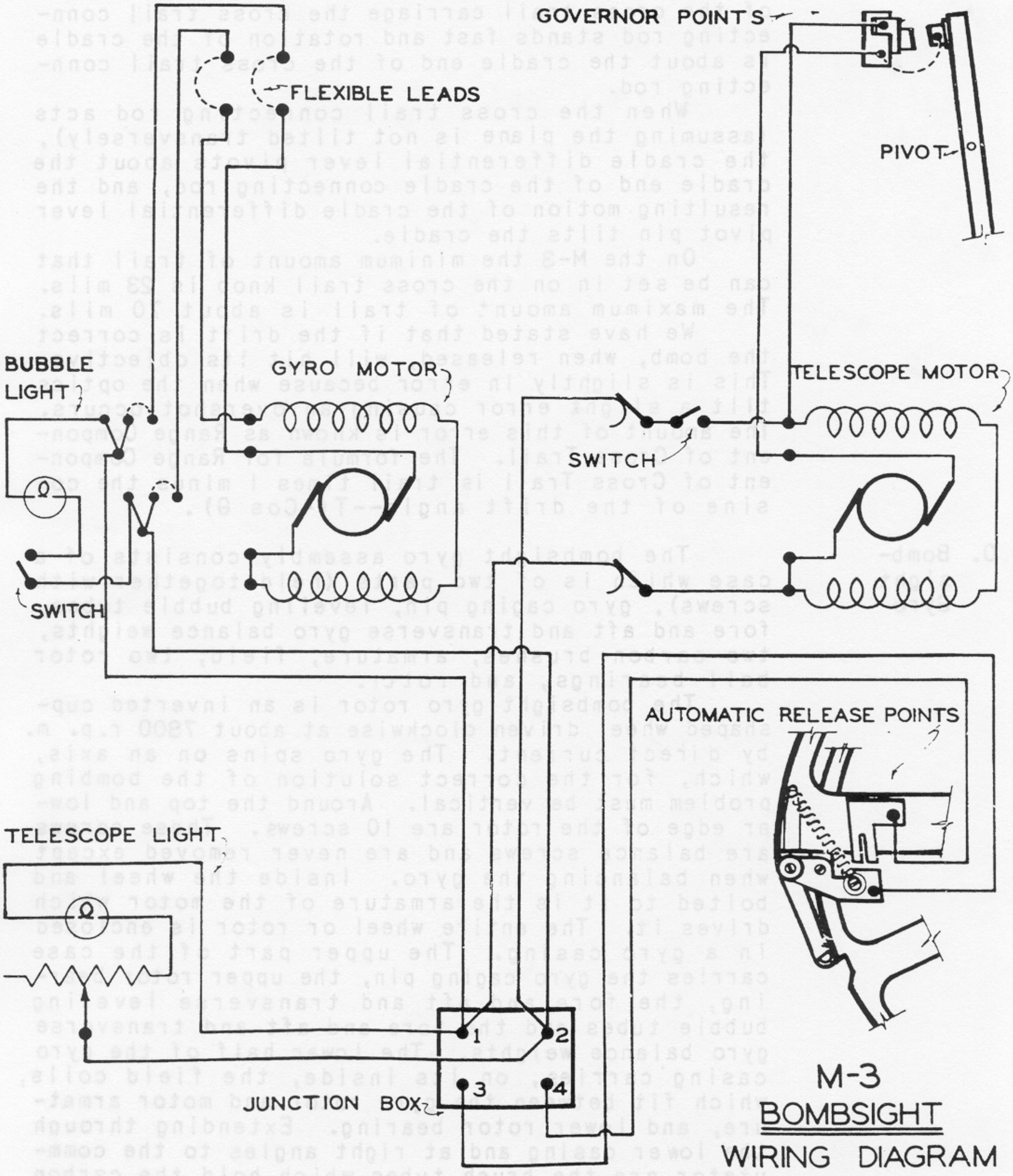

GOVERNOR POINTS
FLEXIBLE LEADS
PIVOT
BUBBLE LIGHT
GYRO MOTOR
TELESCOPE MOTOR
SWITCH
SWITCH
AUTOMATIC RELEASE POINTS
TELESCOPE LIGHT
1
2
3
4
JUNCTION BOX
M-3
BOMBSIGHT
WIRING DIAGRAM

FIG. 36

fixed lead weights used in balancing the bombsight gyro.

The gyro casing is carried in the bombsight cardan by fore and aft gudgeons working in ball bearings. The gyro stabilizes the cardan in a fore and aft plane through these gudgeons and bearings, and stabilizes the telescope cradle in a transverse plane by means of the cradle connecting rod.

P. Sight Cardan

The cardan furnishes support for the fore and aft bearings of the gyro in its left half and support to the fore and aft bearings of the telescope cradle in its right half. The cardan is supported by gudgeons working in ball bearings in the case, known as the right and left cardan gudgeon bearings. The right cardan gudgeon is drilled to permit the telescope cable to pass through its axis, and is a fixed bearing.

Q. Explanation of Bombsight Wiring M-3

Fig. 36

The power for operating the bombsight comes from the plane's supply. The power enters the stabilizer female cannon plug through the number two pole, from the number two pole to the bombsight switch to the number two pole of the female sight cannon plug. From number two pole the current goes to the sight gyro, bubble light and reticle light and to the telescope motor, There is a circuit from poles three and four of the stabilizer female cannon plug to poles three and four of the sight female cannon plug and then to the automatic release points, through the points to an electro-magnetic relay in the bombracks.

Consider the circuit to the bombsight gyro. The current goes from the bombsight switch to the number two pole of the bombsight cannon plug to the flexible lead from the case to the cardan to the flexible lead from the cardan to gyro housing to the sight gyro through the field coils and armature across flexible lead from the gyro to the cardan, across the flexible lead from the cardan to the case and then to the number one pole which is the ground.

The current to the gyro branches to the bubble light and passes through the same flexible leads and circuit to number one pole.

Another circuit goes directly from number two pole to the rheostat reticle light. This light is is used to light the cross hairs for night bombing.

TELESCOPE CRADLE ASSEMBLY

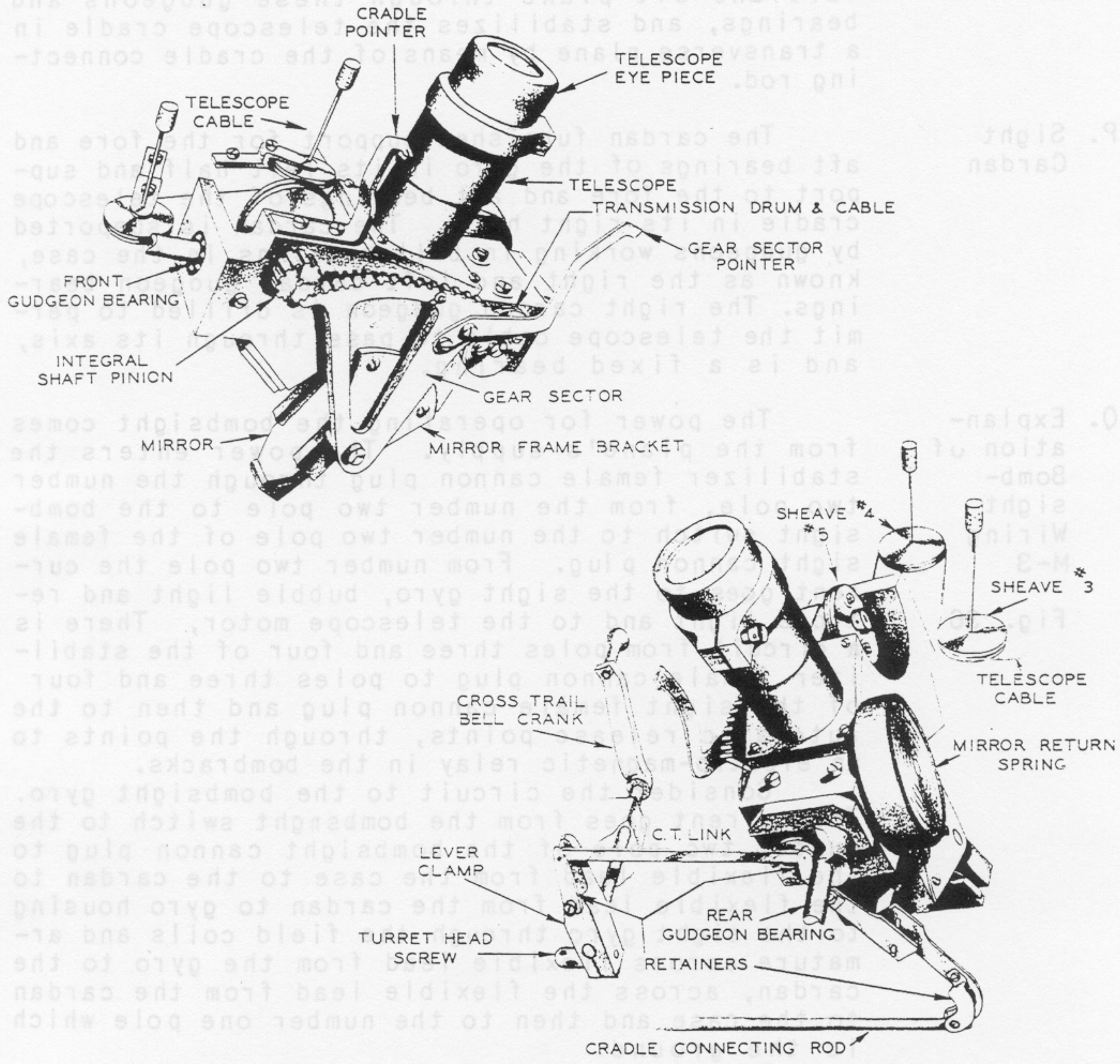


FIG. 37

The telescope motor circuit goes from the number two pole to the telescope motor switch, from the switch to the terminal block, branches through the field coils and governor points. The current goes through the governor points to the armature through the armature to the terminal block and back to the number one pole. The current to the field coils goes through the coils, wired in parallel with the armature, to the terminal block to the ground pole. The armature of the telescope motor is wired in series with the governor points. Thus when the contact between the points is broken the motor stops. This arrangement controls the speed of the telescope motor.

R. M-6 Sight

1. Improvements and Changes of M-6 Series Over M-3 Series

1. One wire electrical system (additional wires crossing bearings).
2. Removable eyepiece to allow easy cleaning and installation of filters.
3. Front view glass is easily removable.
4. A luminous dial on telescope and rate indicators.
5. Double precessing knobs. Spring tension only on the large knob for fine adjustments, and the small knob, for coarse adjustments, is direct contact.
6. Increased sighting and dropping angle, i.e. 70°.
7. Additional forward view mechanism (adds 7° in M-6 sights and 20° additional in M-6-M and M-9 sights.) N.O.P. #649
8. A pin is used to attach the sight to stabilizers instead of a locking nut.
9. The trail and cross trail mechanism are redesigned to accommodate 150 miles each. Trail in cross trail mechanism is automatically set in with trail. N.O.P. #650
10. A double cable and an extra sheave are used to transmit the tension of a mirror return spring.
11. The telescope is semi-rigid and tilts for cross trail only. Fig. 37
12. An optical mirror rotates instead of the telescope.
13. The trigger is a squeeze type release trigger.
14. The bubble light is a part of the bubble mounting block.

15. A gear shift increases the limits of the disc speed from 101 to 593.
16. The telescope has finer cross hairs, 1/4 mil. The optics are increased in power from 1.5 to 2.2.
17. The ratio between the drift and turn knobs is 7.25 to 1.
18. The automatic release points are changed from knife switch type to contact type.
19. The cannon plug is increased to sixteen poles (see cannon plug diagram).
20. A precession motor is an integral part of the stabilizer. (No longer used).
21. The end play of turn knob shaft is adjustable and under spring tension.
22. The center of focus of the optics is: 3/16" to the rear, 5/16" to the right, and 1" lower from the sight stem sleeve.
23. THE SIGHT AND STABILIZER OF DIFFERENT SERIAL NUMBERS ARE INTERCHANGEABLE WITH ADAPTATION.
24. The dropping angle is increased, It is now 25 mils to 1800 mils with 50 mils trail. It has a range of 1700 mils with 150 mils trail.
25. There are no vents in the sight.
26. The sight power cable enters the junction box nearer the bottom.
27. The ground speed drum has a clock-like spring and an idler gear. (Prism is eliminated in the M9 series).
28. The telescope coincidence scale has only a single mark, at zero.
29. It is possible to set zero trail in the cross trail mechanism.
30. The "on" and "off" position of the switches is reversed.
31. An auxiliary search knob has been added to obtain the additional sighting angle.
32. The inside parts of the rate end are no longer plated: this prevents peeling.
33. The caging knob is no longer adjustable for the vertical.
34. A spring has been added to the auxiliary search knob to assure positive disengagement on M6M.
35. The ground speed drum reading has been increased to 480 knots on the M6M.
36. Safety guards are provided for the stabilizer and servo switches.
37. A shield has been added to the later models, in order to protect the cross trial bell crank assembly.

38. In later models the stabilizer hs three instead of four mounting bolts.

39. The servo and telescope motors have 500 ohm resisters wired in parallel. These prevent arcing and burning of the isolated sector brush and telescope motor points.

40. In the later models the sight stem has a stop pin which limits the rotation of the sight at 32° in each direction.

S. Mechanical Solution of the Cross Trail Problem M-4 and Up.

Fig 35

When the trail is set in on the trail arm, the cross trail rack is moved towards the front of the sight by means of a pinion gear which is mounted on the trail arm pivot. The forward movement of the cross trail rack is transmitted through a bell-crank and a linkage system to the yoke. Due to the action of the bell-crank, the yoke is moved to the rear. Since the yoke encircles the disc, upon which the stud is attached, the disc and stud are both moved to the rear of the sight stem a distance proportional to trail. When the correction for drift is made, the stabilizer is turned under the sight, thereby causing the dovetail to swing through an arc relative to the fore and aft axis of the sight. Since the disc and stud are eccentric to the center of the sight stem, the stud will travel through an arc relative to the bombsight. Because the stud is engaged in a slot in the cross trail carriage, the angular movement of the stud is translated into a linear movement of the cross trail carriage. The movement of the carriage is, in turn, transmitted through a bell-crank and the differential lever to the optics. The cradle is then tilted through an angle which will cause the optics to subtend cross trail distance on the ground.

T. Forward View Mechanism M-6 7 degrees

On the M-6, early models, the forward view mechanism consisted of an auxiliary search knob geared to the cable operating sheave. which is geared to the telescope quadrant.

Seven (7) degrees can be added to the sighting angle making a total of 77° sighting angle.

The extra degrees of sighting angle can be set in only when the telescope quadrant is at maximum sighting angle. When the telescope quadrant is at maximum position the camway follower or stud is at the end of the camway. The camway has an L shape projection, and when the auxiliary search knob is rotated the L shape projection

20 DEGREE FORWARD VIEW MECHANISM

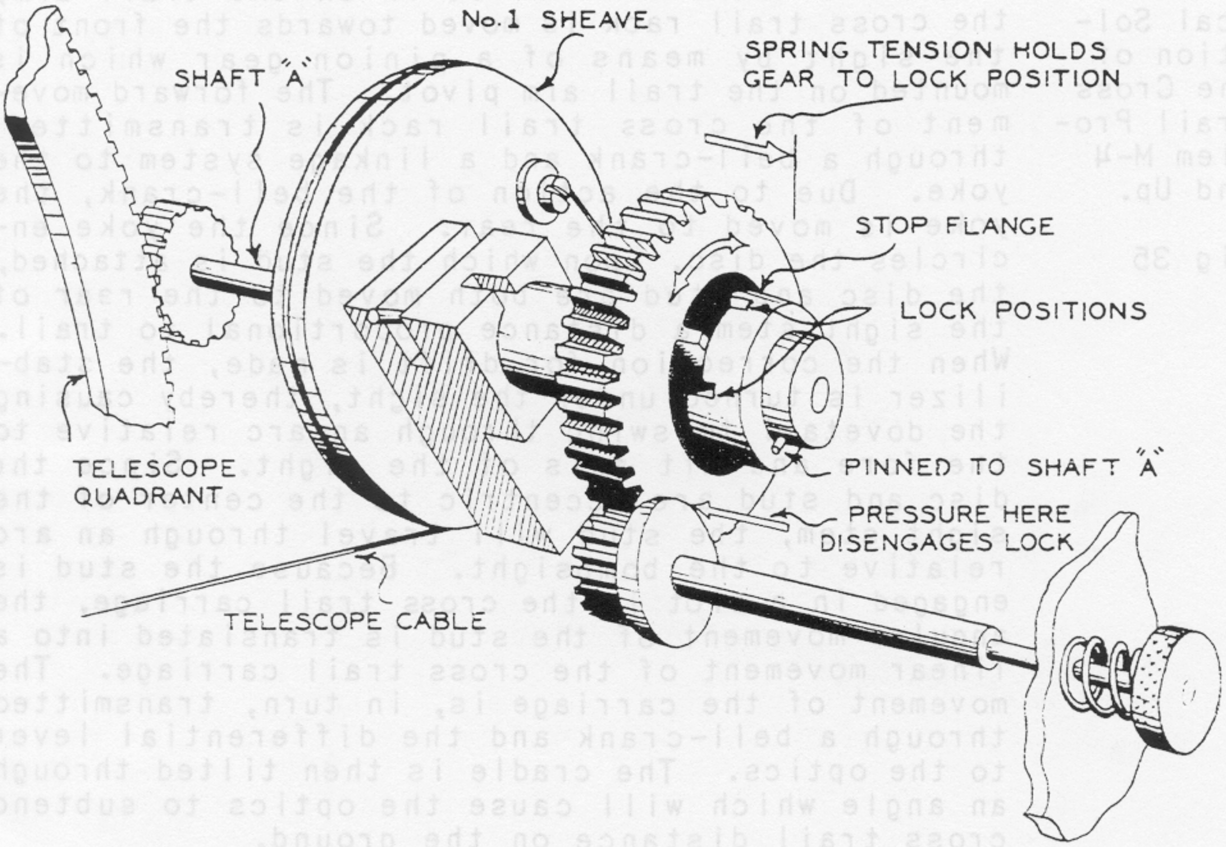


FIG. 38

permits the quadrant to be rotated 7 degrees. While the seven extra degrees are set in, the quadrant cannot be rotated because the stud hits the projection and the camway is above the stud. The auxiliary search knob must be held in position if the extra sighting angle is utilized because the quadrant return spring will force the quadrant back to maximum position, or 70° sighting angle.

It must be remembered that in the M-6 series with 7 degrees extra sighting angle the entire quadrant is rotated 7 degrees and that the extra degrees can be set in only when the telescope quadrant is at 70 degrees sighting angle and that the auxiliary search knob must be rotated and held in place if the 7° is obtained.

M-6 Later Models 20 Degrees

The later models of the M-6 series has a 20 degree forward view mechanism. This mechanism consists of an auxiliary search knob, spring and intermediate gears.

Fig. 38

The construction of this mechanism permits setting in of the additional 20° independently of the position of the telescope quadrant.

The 20° extra sighting angle is set in as follows. Push in on the auxiliary search knob and turn clockwise. When the auxiliary knob is pushed in the forward view engaging gear is pushed in and the projection on that gear is disengaged from the notch in the cable operating shaft collar. Rotate the auxiliary search knob clockwise. The eccentric clamp is notched for the projections on the engaging gear and the two are always engaged. The eccentric clamp is slotted and in the operating shaft. This pin acts as a stop if the collar becomes worn and no longer stops the forward movement of the auxiliary search knob.

The notches in the cable operating shaft collar are spaced so that as the engaging gear and cable operating sheave are rotated the mirror is turned through an angle of 20 degrees. A spring inside the engaging gear keeps it engaged once the projection is in the notches of the operating shaft collar.

The spring on the auxiliary search knob shaft is for positive disengagement of the auxiliary search knob shaft pinion and the engaging gear on the cable operating shaft.

The additional 20 degrees sighting angle gives a total sighting angle of 90 degrees.

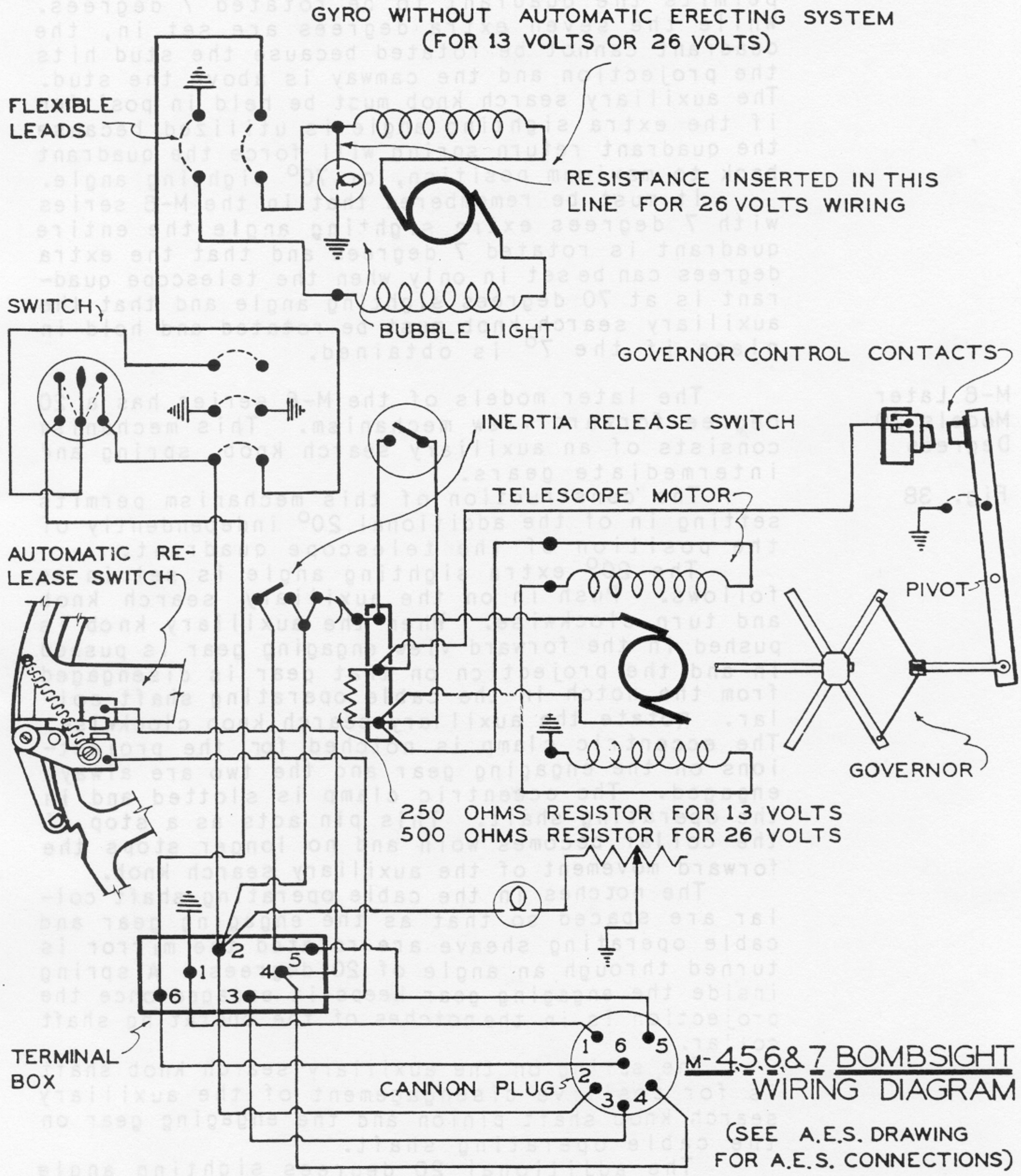

GYRO WITHOUT AUTOMATIC ERECTING SYSTEM
(FOR 13 VOLTS OR 26 VOLTS)
FLEXIBLE LEADS
RESISTANCE INSERTED IN THIS LINE FOR 26 VOLTS WIRING
SWITCH
BUBBLE LIGHT
GOVERNOR CONTROL CONTACTS
INERTIA RELEASE SWITCH
TELESCOPE MOTOR
AUTOMATIC RELEASE SWITCH
PIVOT
GOVERNOR
250 OHMS RESISTOR FOR 13 VOLTS
500 OHMS RESISTOR FOR 26 VOLTS
1
2
3
4
5
6
TERMINAL BOX
1
6
5
2
3
4
CANNON PLUG
M-4,5,6,& 7 BOMBSIGHT
WIRING DIAGRAM
(SEE A.E.S. DRAWING FOR A.E.S. CONNECTIONS)

FIG. 39

The maintenance personnel must be sure that the additional 20 degrees is not set in when the telescope cable is installed.

U. Explanation of Wiring Diagram M-6 Sight

Fig. 39

The M-6 series sights have a one wire electrical system. The circuits are grounded through the case. Flexible leads carry the return current across the bearings and from gyro to cardan and from cardan to case. Number one pole of the sight cannon plug is the ground. Number two pole is the power. Number 3 and 4 go through the automatic release points. Number 5 goes to the inertia release switch. Number 6 goes to the A. E. S. The A. E. S. is no longer used. The circuit to the sight gyro and to the telescope motor is the same as in the M-3 except that the M-6 has the one wire electrical system and the M-3 has a two wire electrical system. See wiring diagram of M-6; also wiring diagram of M-3.

SECTION VI

BOMBING PROBLEM

In World War I the civilian population sought protection in dougouts, cellars and the like, from screaming shells thrown into their city from fixed gun positions.

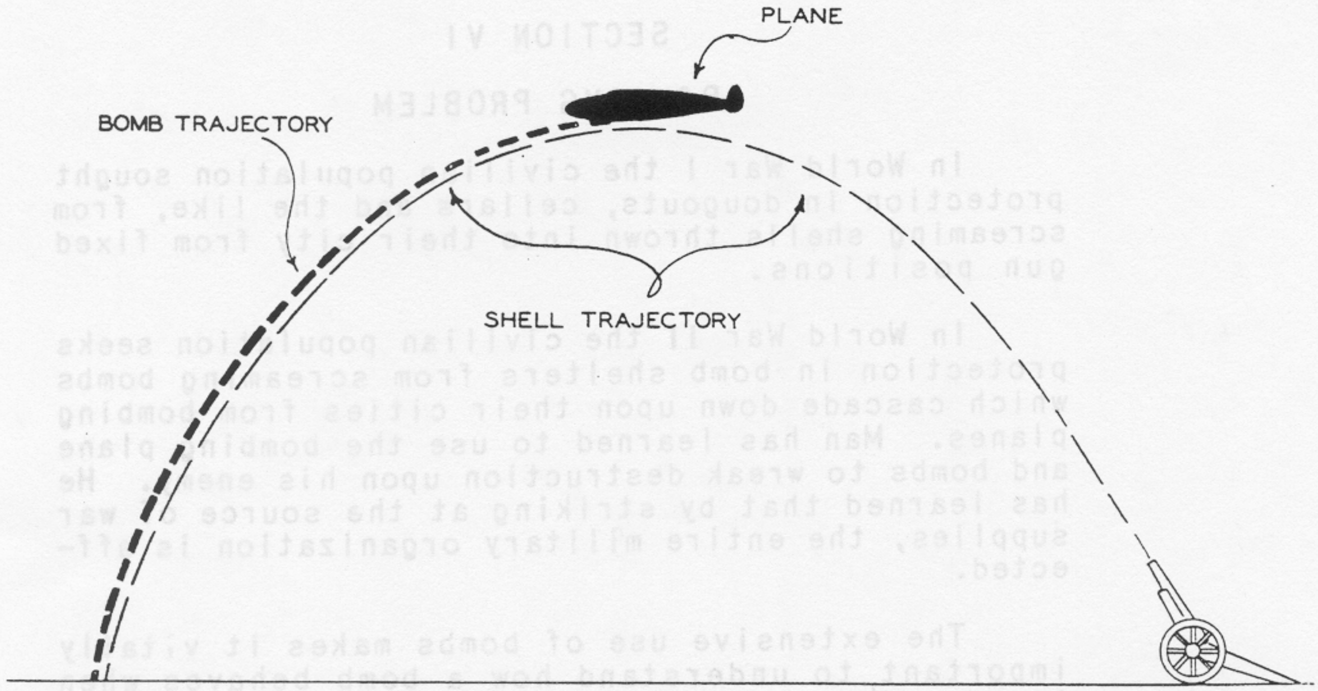
In World War II the civilian population seeks protection in bomb shelters from screaming bombs which cascade down upon their cities from bombing planes. Man has learned to use the bombing plane and bombs to wreak destruction upon his enemy. He has learned that by striking at the source of war supplies, the entire military organization is affected.

The extensive use of bombs makes it vitally important to understand how a bomb behaves when it is released from the plane. Many people think that a bombing plane must be directly over the target before releasing the bomb. This is entirely erroneous.

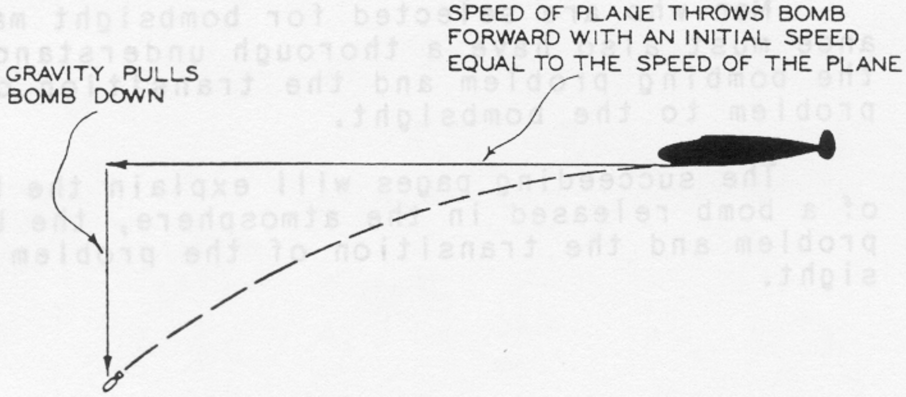
The men who invented the bombsights had a thorough knowledge of the bombing problem before actually constructing the sight.

Men who are selected for bombsight maintenance must also have a thorough understanding of the bombing problem and the transition of that problem to the bombsight.

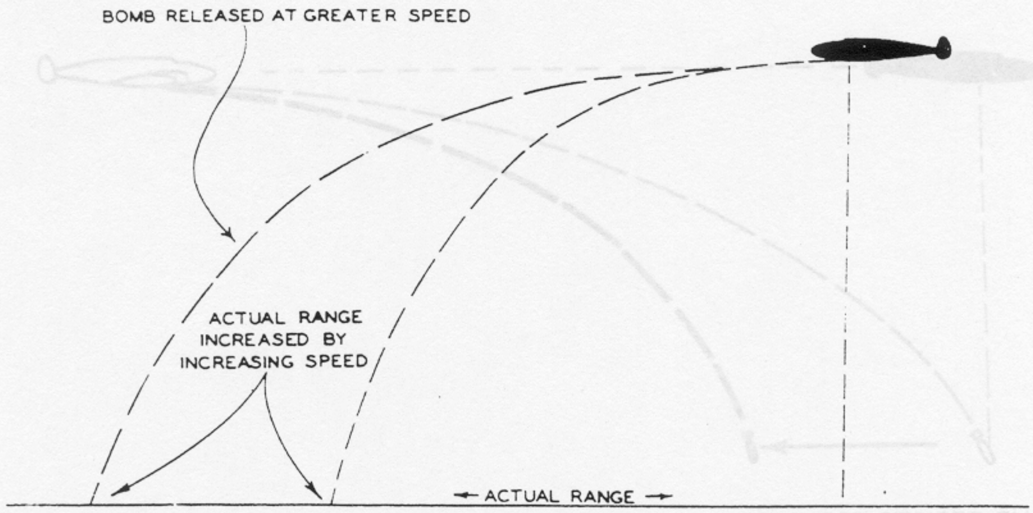
The succeeding pages will explain the behavior of a bomb released in the atmosphere, the bombing problem and the transition of the problem to the sight.



(1) The trajectory of a bomb is similar to the last half of the trajectory of an artillery shell.

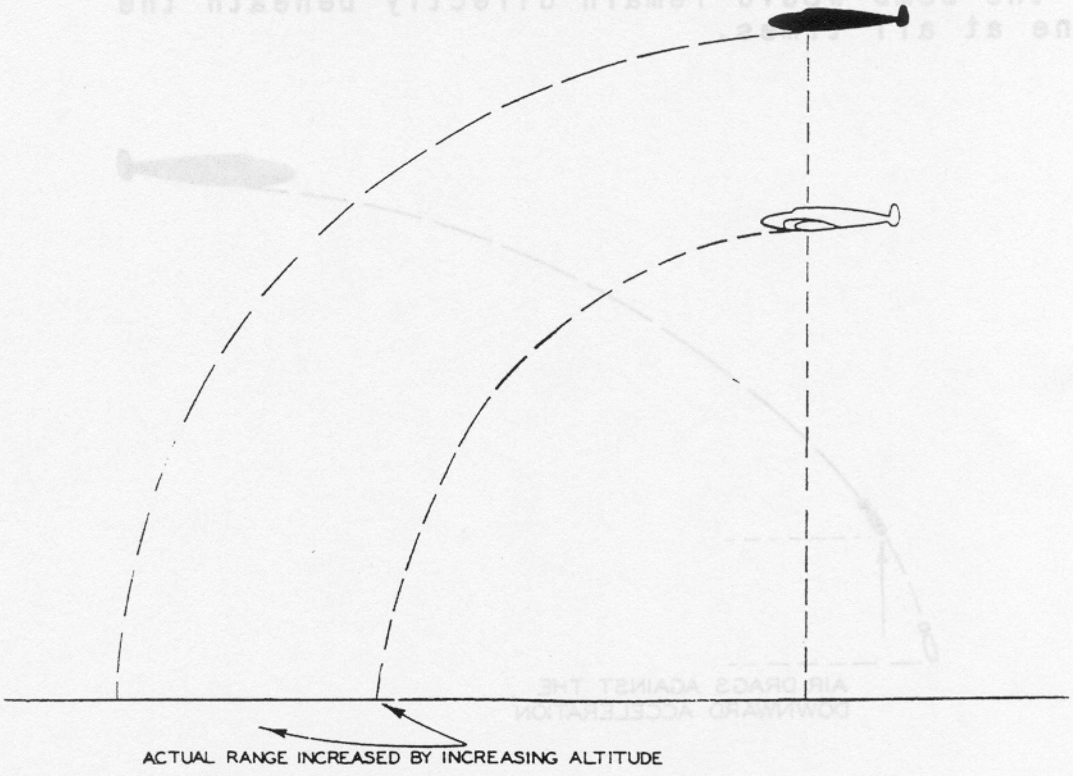

SPEED OF PLANE THROWS BOMB FORWARD WITH AN INITIAL SPEED EQUAL TO THE SPEED OF THE PLANE
GRAVITY PULLS BOMB DOWN

(2) Gravity and speed of the plane cause the bomb to fall along a curved path.

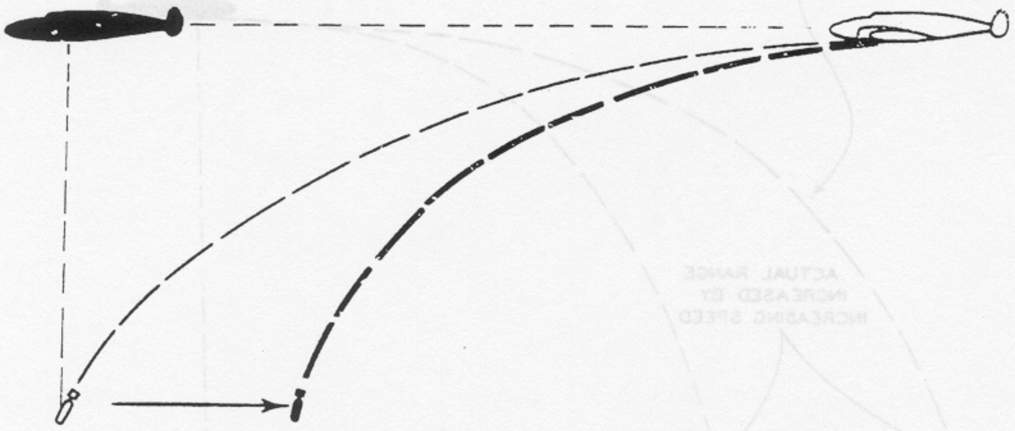

BOMB RELEASED AT GREATER SPEED
ACTUAL RANGE INCREASED BY INCREASING SPEED
ACTUAL RANGE

(3) If the speed of the airplane is increased the bomb would be thrown forward with a greater force, thus increasing the actual range, i.e.

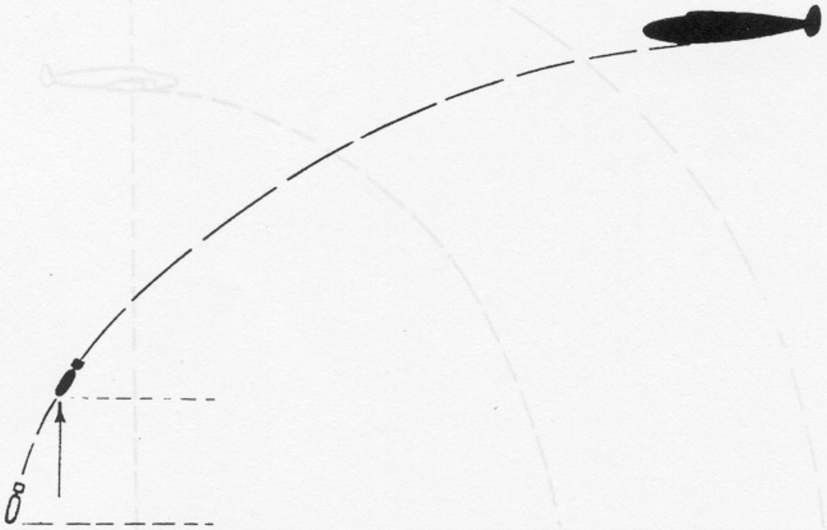
> i.e. Actual range is the distance the bomb travels over the ground from instant of release to instant of impact.



(4) If the altitude is increased without increasing the speed, this will also increase the actual range distance.

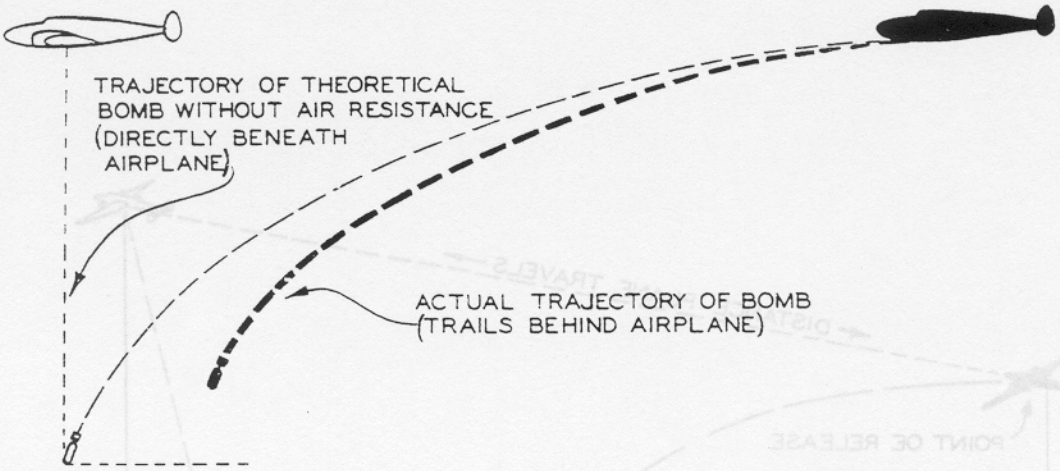


(5) The instant the bomb is free of the plane its forward motion begins to decrease because density of the air resists its forward motion. If this were not true, the forward speed of the bomb would remain the same as the forward speed of the plane and the bomb would remain directly beneath the plane at all times.

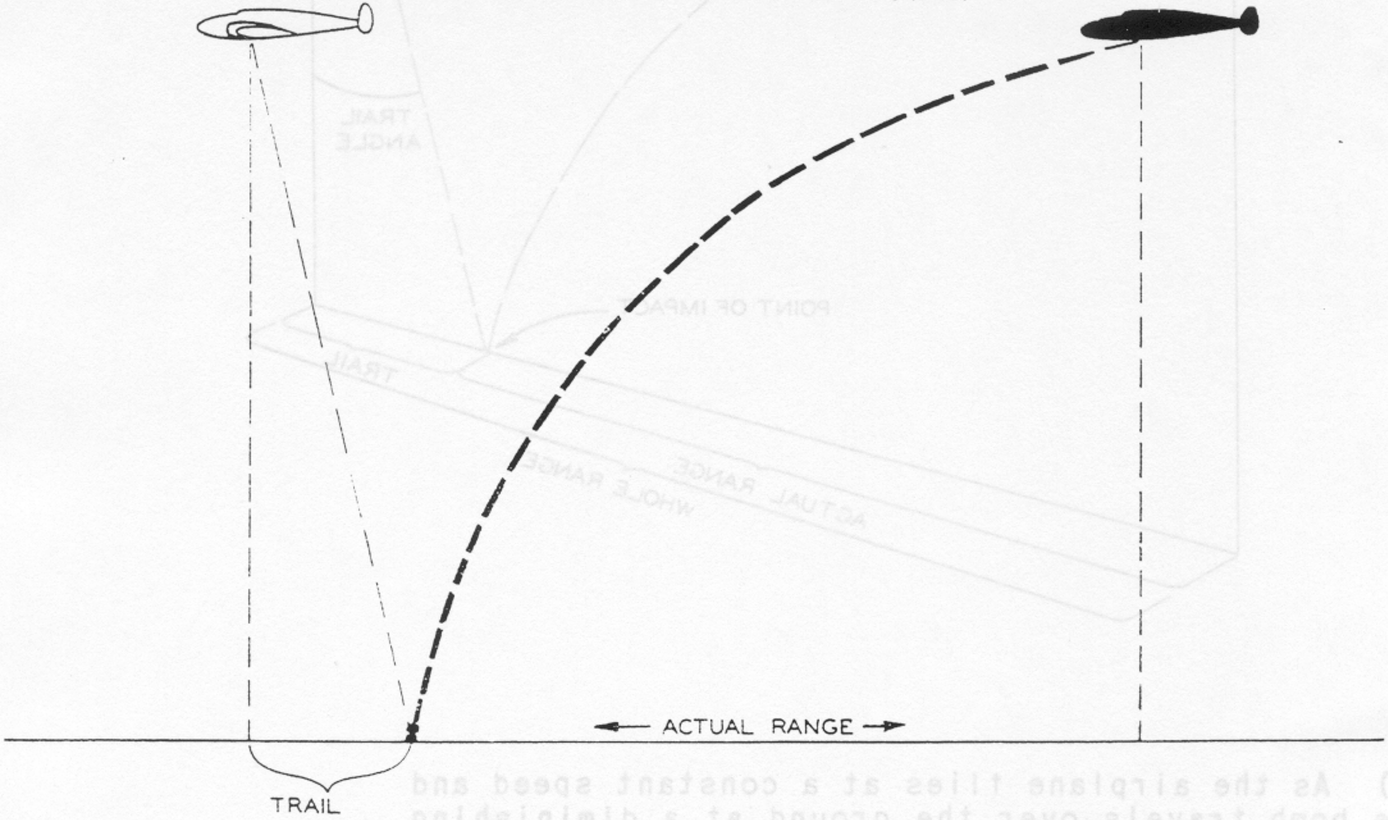


(6) Air density also resists downward acceleration of bomb. i.e.

i.e. Without air resistance a falling body accelerates at 32 feet per second.

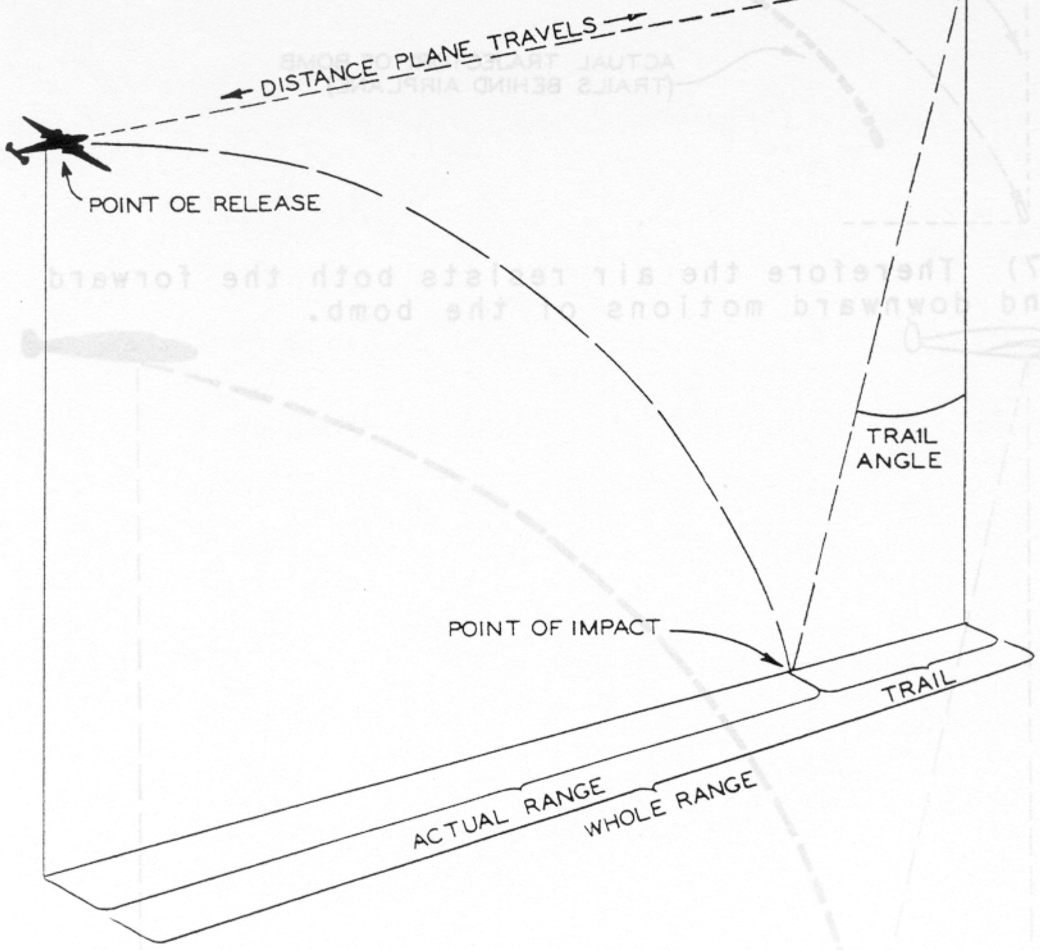

TRAJECTORY OF THEORETICAL BOMB WITHOUT AIR RESISTANCE (DIRECTLY BENEATH AIRPLANE)
ACTUAL TRAJECTORY OF BOMB (TRAILS BEHIND AIRPLANE)

(7) Therefore the air resists both the forward and downward motions of the bomb.

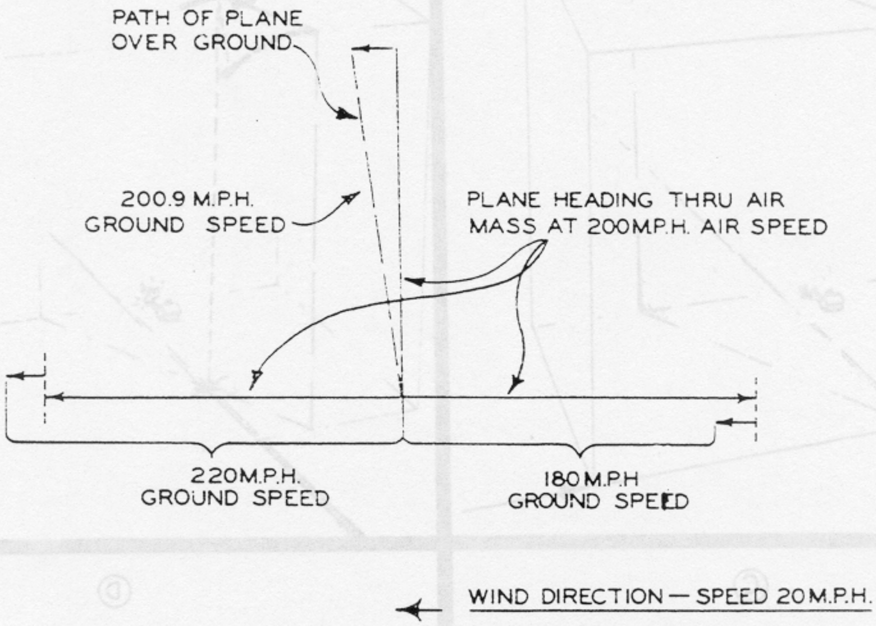


(8) Since the speed and altitude of the plane determine the range of the bomb, speed and altitude of the plane determines the distance the bomb will trail behind the plane at instant of bomb impact. (using one type and weight of bomb i.e.)

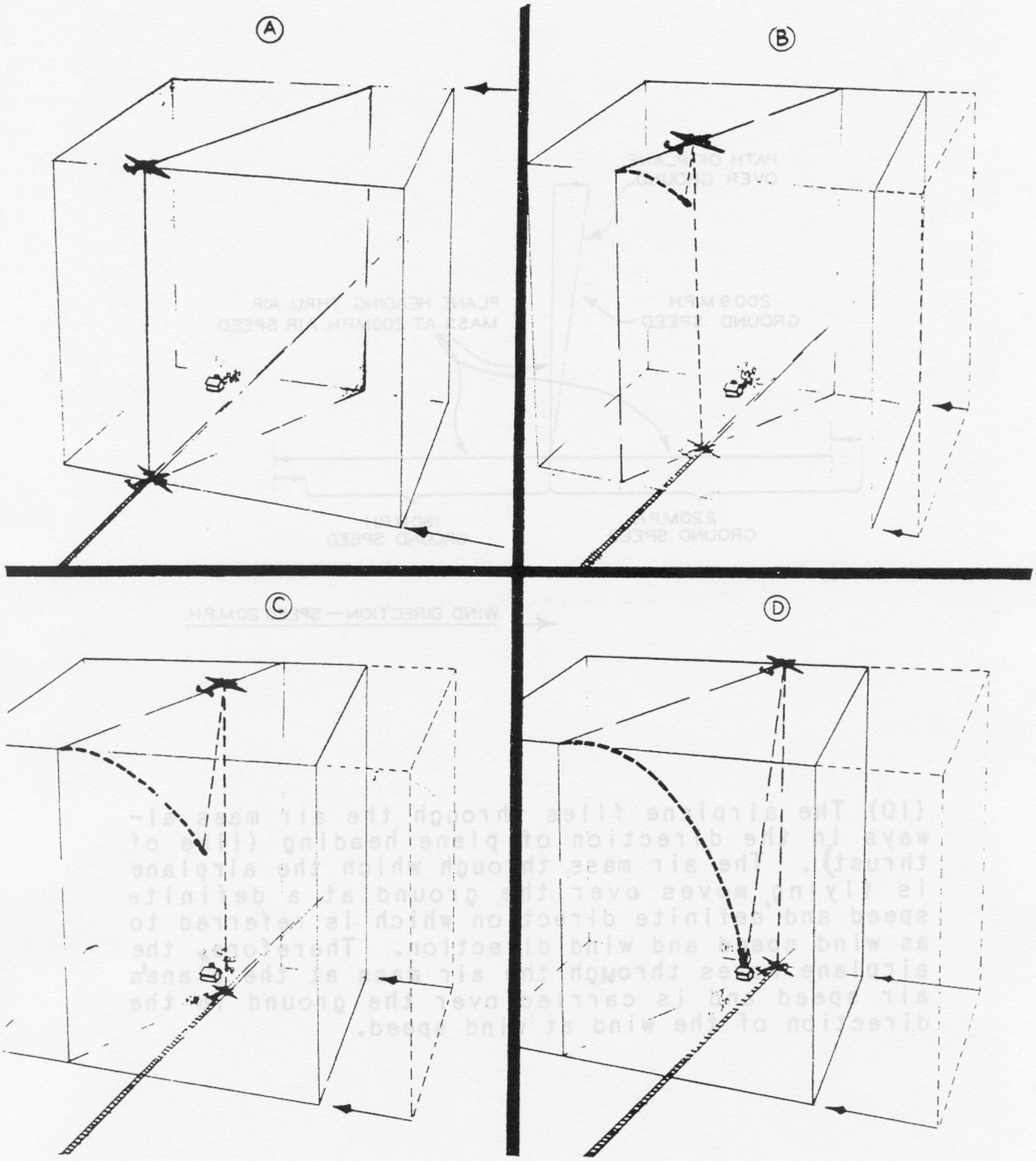
i.e. Different types of bombs will have different trail charts due to the relation of air resistance to their mass (Ballistic Coefficient).



(9) As the airplane flies at a constant speed and the bomb travels over the ground at a diminishing speed, the plane will therefore travel farther over the ground between time of release and time of bomb impact than will the bomb. This distance that the airplane travels is called whole range. The distance the bomb travels is actual range, and the difference between whole range and actual range is trail. The angle formed by the point of impact, the airplane at instant of bomb impact, and the vertical beneath the plane at that instant is called the trail angle.



(10) The airplane flies through the air mass always in the direction of plane heading (line of thrust). The air mass, through which the airplane is flying, moves over the ground at a definite speed and definite direction which is referred to as wind speed and wind direction. Therefore, the airplane moves through the air mass at the plane's air speed and is carried over the ground in the direction of the wind at wind speed.


A
B
C
D

(ii) Figs No. A - B - C - D show:

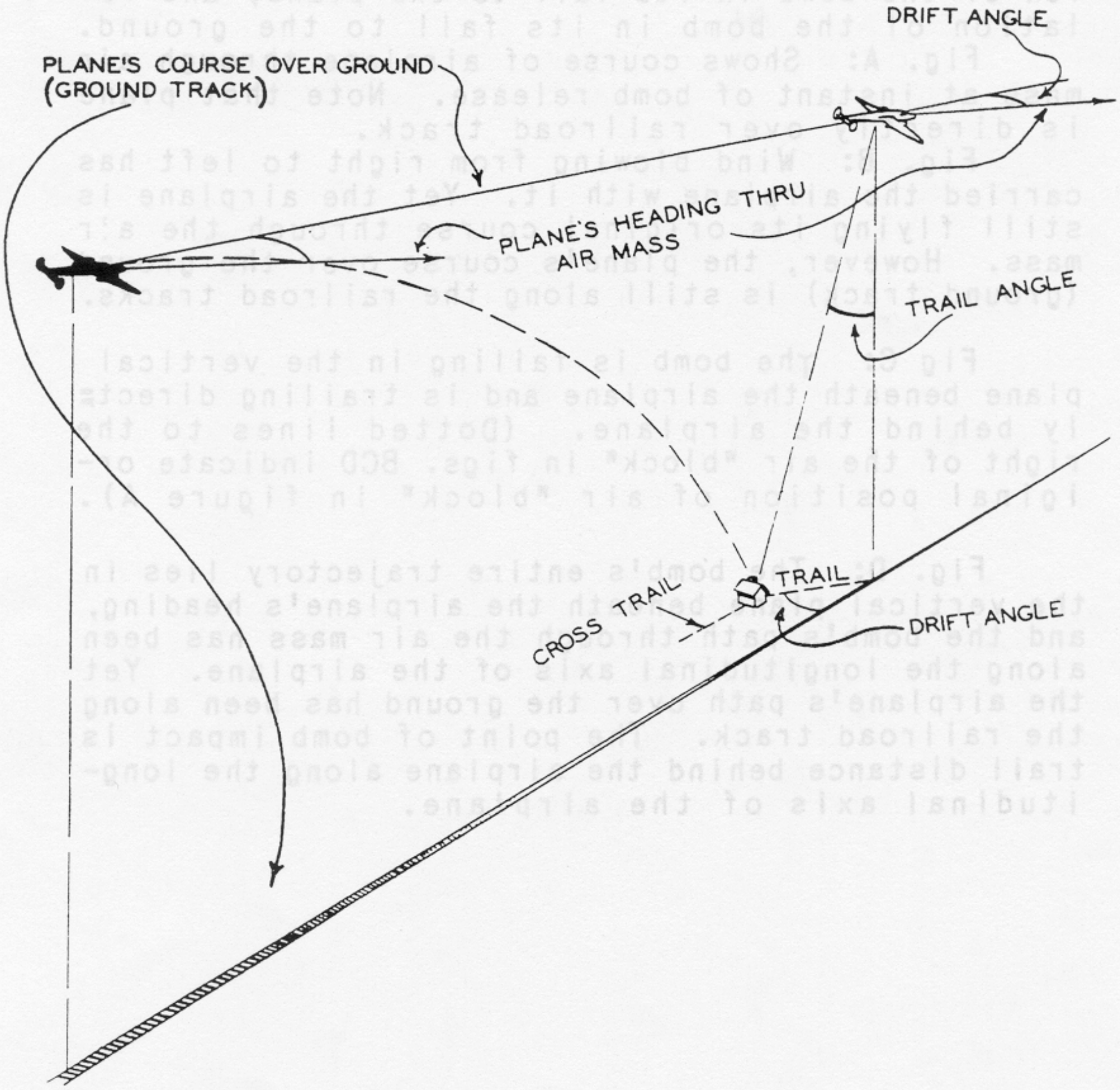
A graphic illustration of the path of a bomb dropped from a plane in a moving air mass; relation of the bomb in its fall to the plane; and relation of the bomb in its fall to the ground.

Fig. A: Shows course of airplane through air mass at instant of bomb release. Note that plane is directly over railroad track.

Fig. B: Wind blowing from right to left has carried the airplane with it. Yet the airplane is still flying its original course through the air mass. However, the plane's course over the ground (ground track) is still along the railroad tracks.

Fig C: The bomb is falling in the vertical plane beneath the airplane and is trailing directly behind the airplane. (Dotted lines to the right of the air "block" in figs. BCD indicate original position of air "block" in figure A).

Fig. D: The bomb's entire trajectory lies in the vertical plane beneath the airplane's heading, and the bomb's path through the air mass has been along the longitudinal axis of the airplane. Yet the airplane's path over the ground has been along the railroad track. The point of bomb impact is trail distance behind the airplane along the longitudinal axis of the airplane.


DRIFT ANGLE
PLANE'S COURSE OVER GROUND (GROUND TRACK)
PLANE'S HEADING THRU AIR MASS
TRAIL ANGLE
TRAIL
CROSS TRAIL
DRIFT ANGLE

(12) The relation of the heading of the airplane through the air mass to the course of the airplane over the ground is the drift angle. The linear distance between the point of impact and the ground track is cross trail. It will be noted that trail is down the longitudinal axis of the plane.

DEFINITIONS

(1) Trajectory	The name given to the path the bomb follows through the air mass from the point of release to the point of impact is known as trajectory.
(2) Gravity	The force exerted by the earth, tending to pull anything to its surface.
(3) Altimeter	An instrument used in airplanes to find the linear vertical distance in feet that a plane is above sea level. This instrument registers the decreasing barometric pressure, computed in feet, that occurs when rising above sea level. It does not give the true altitude in feet that the airplane is above the ground unless the ground is at sea level.
(4) True Altitude	The linear vertical distance that the airplane is flying above the ground. This distance may be found by subtracting the known altitude of the ground from the altitude reading on the altimeter in the airplane. **EXAMPLE:** If the altimeter in the airplane reads 10,000 feet and the ground over which the plane is flying were 4000 feet above sea level, the true altitude would be 10,000 feet--4000 feet or 6000 feet.
(5) C.I.A.S.	"Calibrated Indicated Air Speed" is the air speed reading that will be computed from the air speed indicator in the airplane corrected for installation and mechanical errors.
(6) True Air-Speed	"True Air Speed" is computed by correcting the C.I.A.S. for the change in air density which occurs at any altitude above sea level.
(7) Ground Speed	"Ground Speed" is the speed at which the air plane is traveling over the ground. It is computed by adding or subtracting wind effect from true air speed.
(8) Time of Fall	Time of Fall" is the time it takes for the bomb to fall to earth from the time of release to the time of impact.

(9) Whole Range	"Whole Range" is the distance that the airplane would travel during the time of fall of the bomb, or from the time of release to the time of impact (provided the airplane maintains its speed and course). This distance may be computed by multiplying the ground speed by the time of fall.
(10) Trail	Trail is the linear distance measured from a point vertically beneath the airplane at the instant of impact to the point of the impact. Air resistance to the forward and downward motion of the bomb is the cause of trail.
(11) Actual Range	Actual Range is the linear distance measured along the ground from a point vertically beneath the airplane at the time of release to the point of impact. This distance may be computed by subtracting trail distance from whole range.
(12) Actual Range Angle (Dropping Angle)	The angle between the line of sight to the target and the true vertical at the instant of release. Will subtend actual range distance upon the ground.
(13) Sighting Angle	The angle between the line of sight to the traget, and the vertical from the plane to the ground at any instant. At the time of release it is equal to the Dropping or Actual range angle.
(14) Cross Trail	The distance a bomb falls to the downwind side of the ground track due to the drift angle and the fact that the bomb always trails directly behind the airplane which dropped it. Cross trail is equal to the product of the trail in feet and the sine of the drift angle.
(15) Drift Angle	The angle between the plane's heading and the ground track.
(16) Trail Angle	"Trail Angle" is the angle formed at the instant of bomb impact by a line vertically beneath the plane to the ground and a line from the plane to the point of impact (at the instant of bomb impact).

(17) Velocity of Closure

"Velocity of Closure" is the velocity at which the airplane is closing with the target. If the target is stationary, the "Velocity of Closure" is equal to the ground speed of the airplane. If the target is moving, it is the Ground Speed plus or minus the Ground Speed of the moving target.

EXAMPLE: If the target is moving at a ground speed of 30 m.p.h. in the same direction as the airplane and the airplane's ground speed is 250 m.p.h., the Velocity of Closure is 220 m.p.h. If the target is moving toward the airplane at a ground speed of 30 m.p.h. and the airplane has a Ground Speed of 250 m.p.h., the Velocity of Closure is 280 m.p.h.

Synchronous Sight

The type of bombsight used in high level precision bombing is a synchronous sight. The term "synchronous" means that one thing will maintain the same relationship to another under constantly changing conditions. In a synchronous bombsight, that means that the rate of angular drive of the optics keeps pace with the rate of angular change of the sighting angle--provided the sight is synchronized. This means that when the sighting angle is say 50° and the transverse hair rests synchronized upon the target, when the sighting angle reaches 40°, the transverse hair will likewise be at 40° from the vertical and in that condition rest upon the target.

When sighting through the optics, there are two points; one above and one below the transverse hair. The first is the position of the eye which sights to the transverse hair; the second is the point of projection to the ground of this line of sight. As the plane approaches the target, with sight synchronized, the point of projection would move along the surface of the earth at a speed equal to velocity of closure. The fact is that the transverse hair (and therefore this point of projection) remains on the target and doesn't move relative to it. This is because the "forward" velocity of closure of the plane is equalled exactly by the "rearward" velocity of the point of projection relative to the target. All this means the rate of angular closure of the transverse hair is exactly equal to the rate of change of the sighting angle.

No sight synchronizes itself: It must be properly adjusted and operated in order for synchronization.

The manual act of synchronizing causes the optics to drive at the correct speed for synchronization and sets up the correct actual range angle for the given altitude, velocity of closure, and trail characteristic of the bomb. With this correct actual range angle set up, the bomb should be caused to be released the correct actual range distance away from the target.

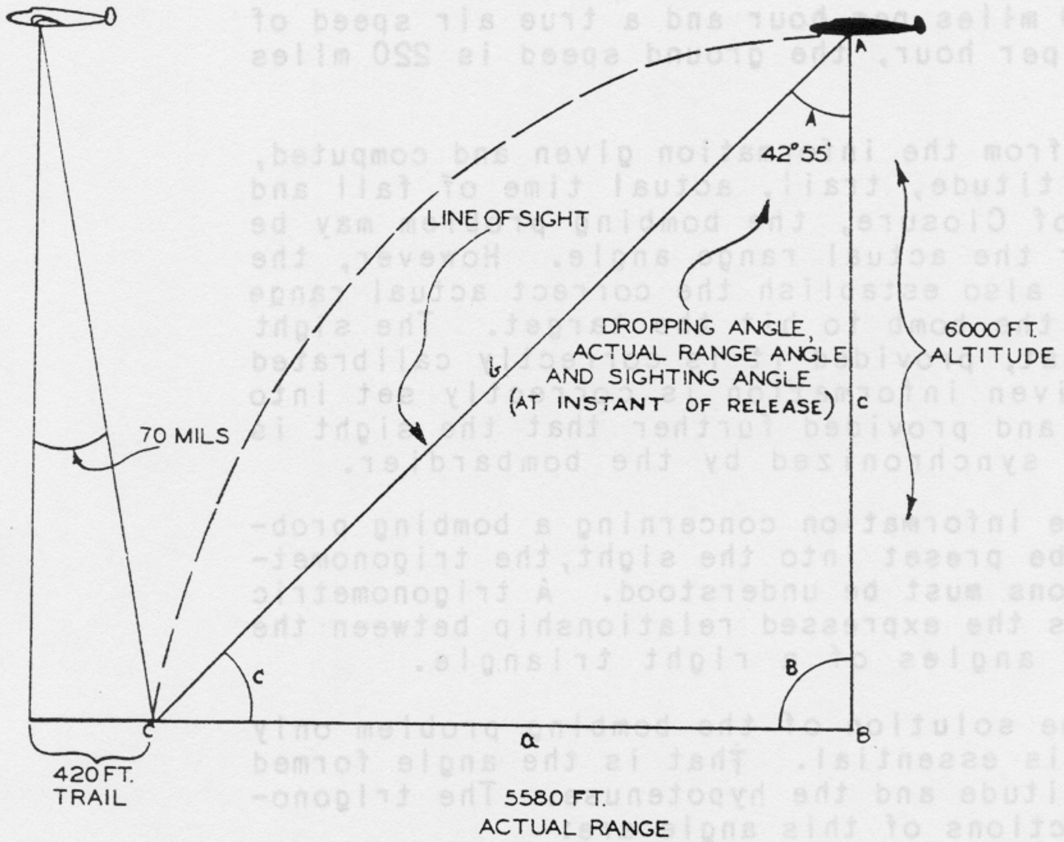
The Norden Bombsight, when synchronized, causes a rate quadrant to be positioned at the correct actual range angle measured off from its zero degrees (tan value) position.

ight
riangle

The path that the bomb travels through the air is the bomb's trajectory. The bomb's trajectory is subtended by the line of sight at the instant of bomb release. Thus, we have formed in space a right triangle. The sides are represented by the altitude and the horizontal distance along the ground the bomb travels from the point of release to the point of impact. This distance is actual range. The third side of the triangle is the line of sight or the hypotenuse.

It is known that in any right triangle the square of the hypotenuse is equal to the sum of squares of the other two sides. Thus, in the right triangle ABC, the equation would be:

$$(AB)^2 + (BC)^2 = (AC)^2$$



The linear distance of AB and BC are determined. AB or the altitude is known and is determined by either instrument readings or the E-6B computer.

From tables, trail and actual time of fall are determined for a particular type of bomb, for a given altitude and calibrated indicated air speed.

It is known that whole range equals Velocity of Closure multiplied by the Actual Time of Fall.

Velocity of Closure is computed from calibrated indicated air speed by the use of tables. First true air speed is determined and then ground speed which is equal to true air speed when there is no wind. If there is a headwind, then the ground speed is decreased by the number of miles per hour the headwind is blowing. Thus, if a true air speed of 200 miles per hour is computed and there is a headwind of 20 miles per hour, the ground speed is 180 miles per hour. Ground speed is also Velocity of Closure. If there is a tail wind of 20 miles per hour and a true air speed of 200 miles per hour, the ground speed is 220 miles per hour.

Thus, from the information given and computed, namely, altitude, trail, actual time of fall and Velocity of Closure, the bombing problem may be solved for the actual range angle. However, the sight will also establish the correct actual range angle for the bomb to hit the target. The sight will do that, provided it is correctly calibrated and the given information is correctly set into the sight and provided further that the sight is correctly synchronized by the bombardier.

If the information concerning a bombing problem is to be preset into the sight, the trigonometric functions must be understood. A trigonometric function is the expressed relationship between the sides and angles of a right triangle.

In the solution of the bombing problem only one angle is essential. That is the angle formed by the altitude and the hypotenuse. The trigonometric functions of this angle are:

Sin $\angle A$ $\frac{a}{b}$ opposite side divided by the hypotenuse.

Cos $\angle A$ $\frac{c}{b}$ adjacent side divided by the hypotenuse.

$\text{Tan } \angle A \quad \frac{a}{c}$ opposite divided by the adjacent side.

Angle **A** is the dropping angle, the actual range angle and sighting angle. Only at the time of bomb release are the dropping angle, sighting angle and actual range angle equal.

If a bombing problem is preset into the sight, the following information must be known.

Altitude
Type of Bomb
Calibrated Indicated Air Speed
Trail
Velocity of Closing

If the actual time of fall is 20 seconds and the velocity of closing is 300 feet per second, whole range is 6000 feet. In other words, the plane would travel 6000 feet from the time of bomb release to the time of bomb impact, provided the airplane continued to fly the same course and at the same speed after bomb release.

See pg. 105 All bombs will trail the plane a certain distance. If the above bomb had 70 mils trail or 420 feet, actual range would then be 5580 feet, or whole range minus trail. Actual range is the distance, measured horizontally along the ground on the collision course that the bomb will travel on its flight through the air.

If the angle which will subtend 5580 feet is determined, the equation would be

$$\text{Tan } \angle A \quad \frac{a}{c} \quad \frac{5580}{6000} = .9300$$

From the trigonometric tables, the tan value $\angle A$ is computed. That value is approximately 42° 55'.

If all the data is correct, then if the telescope and rate quadrants were positioned at the dropping angle of 42° 55' and the bomb released when the cross hairs intersected the target, the bomb should hit the objective. However, the Norden Bombsight, or any synchronizing sight, will determine the correct dropping angle provided the sight is accurately calibrated, the correct data set into the sight, namely, trail and actual time of fall, and the sight is correctly synchronized.

Transition of Bombing Problem To The Sight

1. General

The sight determines the correct dropping angle as follows: Trail for the particular type of bomb is taken from trail charts. The number of mils of trail is set into the sight by rotating the trail arm from zero mils to say 50 mils as indicated by the scale on the trail plate. Actual time of fall, which is also taken from charts, is set into the sight. This is done by positioning the altitude knob so that the proper disc speed may be attained. If 20 seconds is the actual time of fall, the disc speed for an M-6 sight and up is computed by use of the disc speed formula: Disc Speed = Sight constant divided by the actual time of fall. In this case $D.S. = \frac{5300}{20} = 265$ R. P. M.

Use a tachometer and position altitude knob until the disc speed of 265 r.p.m. is obtained. Make three or four checks at 5 to 10 second intervals to be sure the disc speed is correct.

When trail was set in, the roller was positioned from the center of the disc a distance proportional to trail.

The correct rate of drive for the optics is determined by positioning the roller whole range distance from the center of the disc. This is accomplished by rotating the rate knob and through a system of gears the spindle screw is rotated, causing the roller to be moved upward on the spindle screw. When the roller turns it transmits through a system of gears and by means of the telescope cable the drive to the mirror in M-4s and up and to the telescope in the M-3.

When the intersection of the cross hairs remains on the target, as to fore and aft movement, the optics are driving at an angular speed proporportional to ground speed. And if the optics are driving at a speed proportional to ground speed, the rate quadrant is positioned at the tangent function of the dropping angle.

When the indices of the quadrants coincide, the bomb is released provided the release points closed. It must be remembered that the telescope quadrant is positioned at maximum sighting angle at the start of the bombing run and that the rate quadrant is positioned at zero. The rate quadrant can only be moved manually. The telescope quadrant is driven, the driving power being furnished by the telescope motor. The drive is transmitted from the motor to the disc, to roller, through intermediate gears and differential to the telescope rack, which translates the telescope quadrant.

Fig. 40 shows the train of action which takes place in the rate end as the sight solves the bombing problem.

2. Technical

NOTE: The two intermediate gears between the rate gear and rate pinion were added so that the drawing would be less crowded.

Actual time of fall is set into the sight by positioning the altitude knob. The disc speed varies inveresly as the altitude. This is shown by the altitude vector. As the altitude knob is rotated clockwise the speed of the disc increases and the altitude decreases.

When the trail arm is rotated, the roller is raised from the center of the disc a distance proportional to trail, represented by A' B'. As the rate knob is rotated clockwise, the roller is displaced farther from the center of the disc. At the point of synchronization, the roller has been displaced from the disc center a distance proportional to whole range, A' C'. The roller was displaced by the rate mechanism a distance proportional to actual range B' C'.

When the point of synchronization is determined the roller is driving the telescope quadrant at an angular speed proportional to ground speed through the intermediate gears, traction gears, tee head shaft and telescope rack pinion and telescope rack. The drive is transmitted to the mirror (or telescope in the M-3) by means of a bronze cable. The cable operating sheave gear is meshed

SOLUTION OF BOMBING PROBLEM BY RATE END

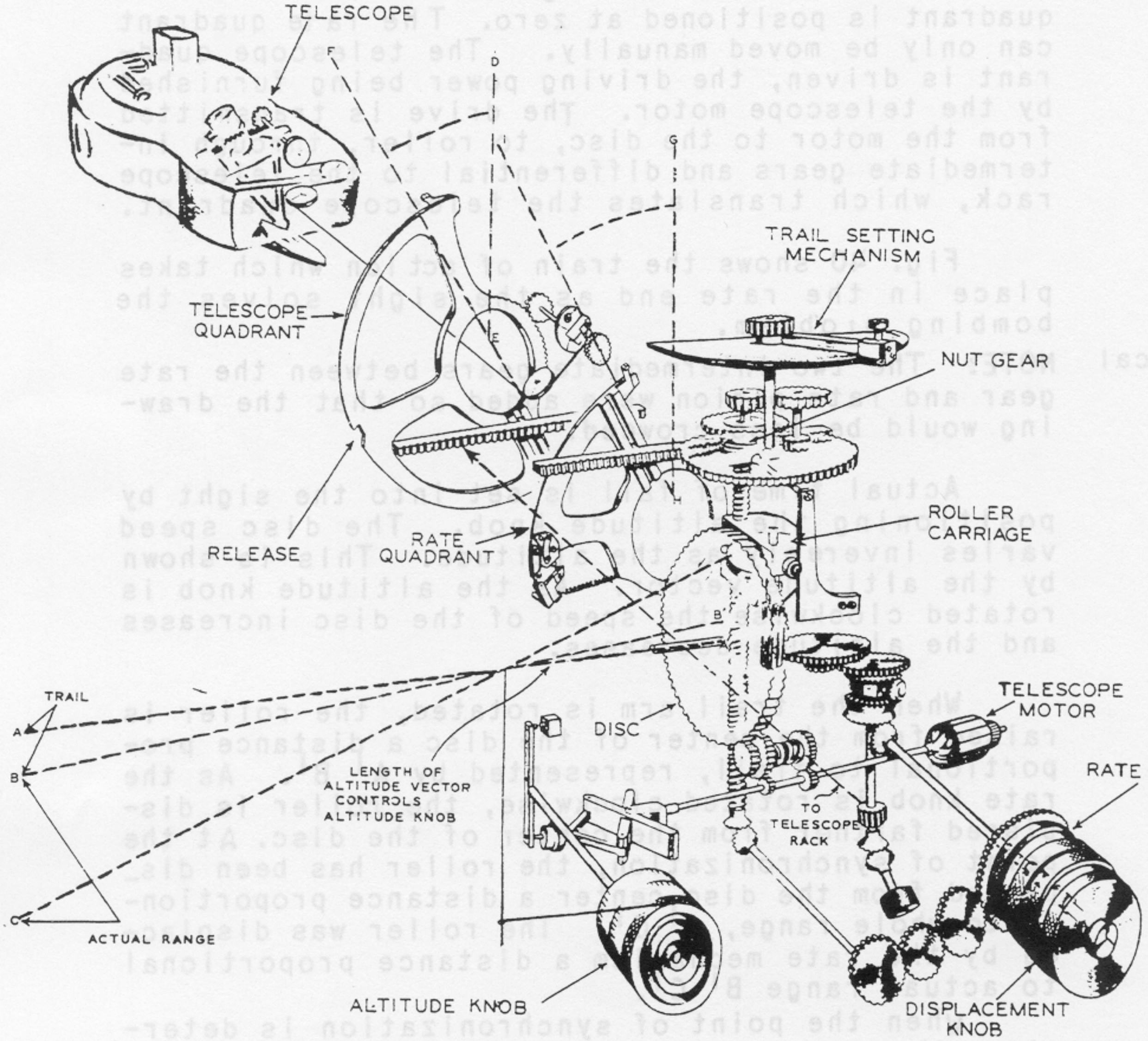


FIG. 40

with the telescope quadrant and the cable passes through the center of the quadrants, through the right cardan gudgeon, over sheaves 3 and 4 to number 5 sheave, which is attached to the telescope cradle. The gear on the #5 sheave shaft is in mesh with the gear sector on the M-6 and with the telescope sector on the M-3. The mirror or telescope is then driven at an angular speed proportional to ground speed.

The telescope is stabilized by the vertical gyro.

In the computing half of the rate end, there are two angles generated by the movements of the two quadrants. The angles are equal and are equal to the angle formed by a line directly beneath the plane to the ground at the instant of bomb release and the line of sight to the ground at the instant of bomb release. These angles are DEF (telescope quadrant) and GHI (rate quadrant). Each angle is determined by the amount the racks are moved. When the indices coincide each rack has been translated a distance proportional to actual range. There is also an angle equal to DEF (telescope quadrant) formed through the telescope by the line of sight and the vertical.

If this angle were projected downward assuming the sight is in an airplane, the angle would subtend actual range distance on the ground.

The small triangle formed within the sight has for its legs the altitude vector and the linear distance the rate rack is driven in translation as the roller is displaced from the disc center by the rate mechanism. The acute angles of this triangle are proportional and similar to the angles DEF and GHI. The rate quadrant is positioned at the range angle determined by the point of synchronization. The angle formed by the rate quadrant, as it is positioned, is the generated range angle and is equal to the sighting angle and the dropping angle at the instant of bomb release.

The telescope quadrant is driven, and at the determined range angle the indices coincide and at that point the angles DEF and GHI are equal. It is important to remember that the position of the rate quadrant will determine the dropping angle computed by the sight. If this angle is incorrect the bomb will miss the objective. To eliminate errors the sight must be accurately calibrated and the correct trail, etc., must be set into the sight.

SIMPLIFIED CROSS TRAIL MECHANISM AND CROSS TRAIL PROBLEM

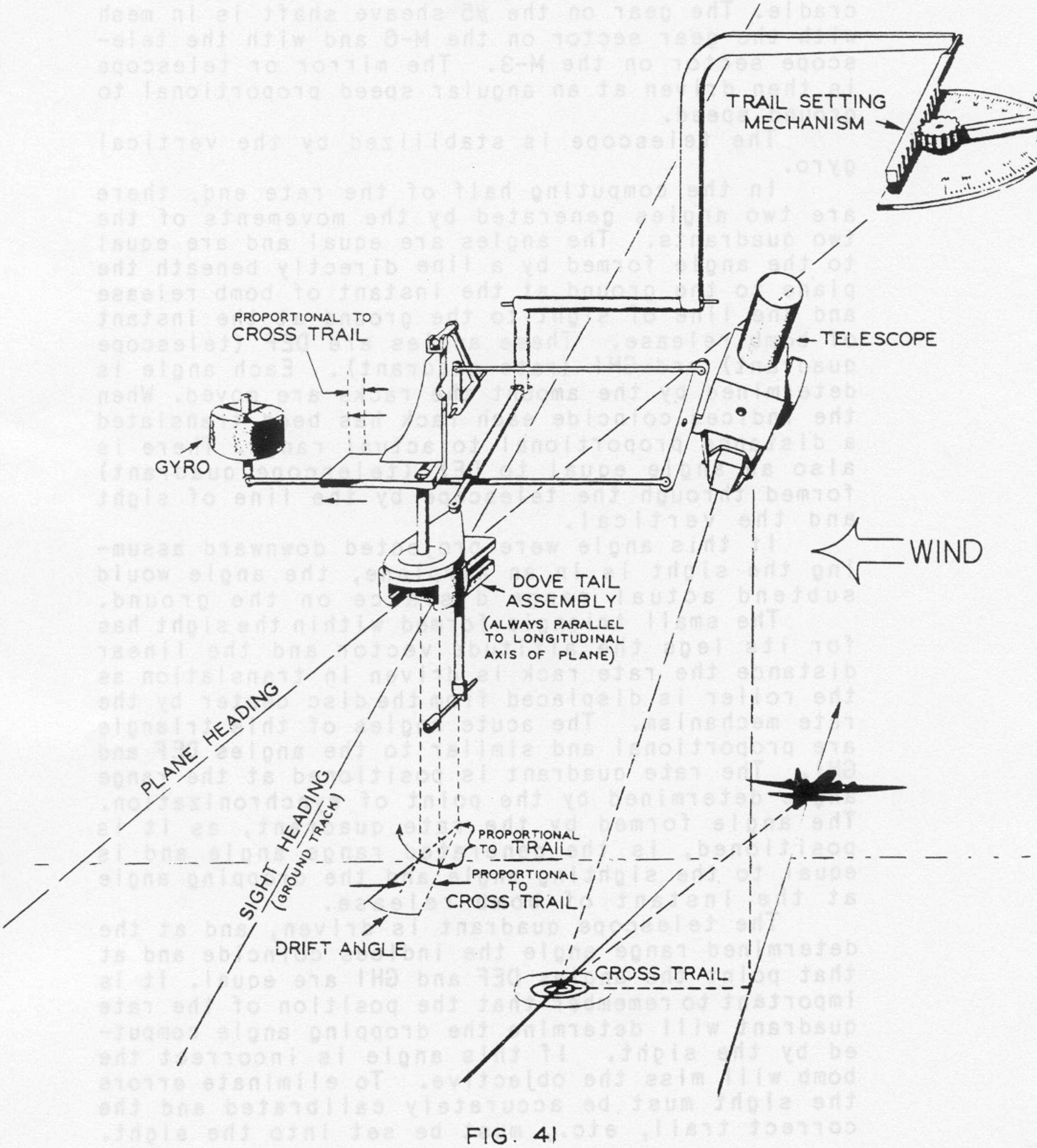


FIG. 41

When bombing with a cross wind condition and when drift is encountered the rate end solves the problem exactly as in case of no cross wind or drift. Refer to the cross trail drawing, Fig.41, to see how the sight corrects for cross trail.

Trail is set in on the cross trail knob (M-3) and trail mechanism. (See cross trail drawing M-6). When the trail arm is rotated, the eccentric disc and roller are displaced from the center of the dove tail and disc respectively a distance proportional to trail.

The cross hairs are placed on the target and checked to see whether the fore and aft cross hair moves off the target in a transverse direction. If it does, rotate the turn knob until the fore and aft hair is again on the target and then the course knobs may be double gripped to keep the hair on the target. Refer to cross trail drawing to see what happen when the course knobs are double gripped. Since the dovetail is a part of the sight stem, and since the sight stem is fastened to the stabilizer, the sight stem will turn with the stabilizer and independently of the sight. As the sight stem pivots, the eccentric disc will pivot through an arc and in so doing the stud, which fits in the slot of the cross trail carriage, will move the cross trail carriage in a transverse direction. This transverse movement is translated through bell crank and cross trail connecting link to the cradle differential lever and to the telescope which is tilted an angular distance that will subtend cross trail on the ground. (The cross trail drawing, Fig.41, shows exactly the relationship between the triangles formed by the movement of the dove tail and sight stem and the tilting of the optics and resulting triangle). As is shown, in order to keep the fore and aft hair on the target the plane's ground track is upwind of the collision course cross trail distance and parallel to the collision course.

Fig.42 shows why there is no transverse movement of the cross trail carriage unless trail is set in on the cross trail mechanism.

Synchronization is accomplished in the same manner as when bombing with no cross wind.

GYROSCOPE

A. Review

1. Definition.

A gyroscope is a flywheel so mounted that only one point, its center of gravity, is in a fixed position, the wheel being free to turn in any direction about this point. Such a wheel has three angular degrees of freedom.

2. Explanation

The wheel or rotor revolves in bearings in a

ECCENTRIC DISC AND DOVE TAIL

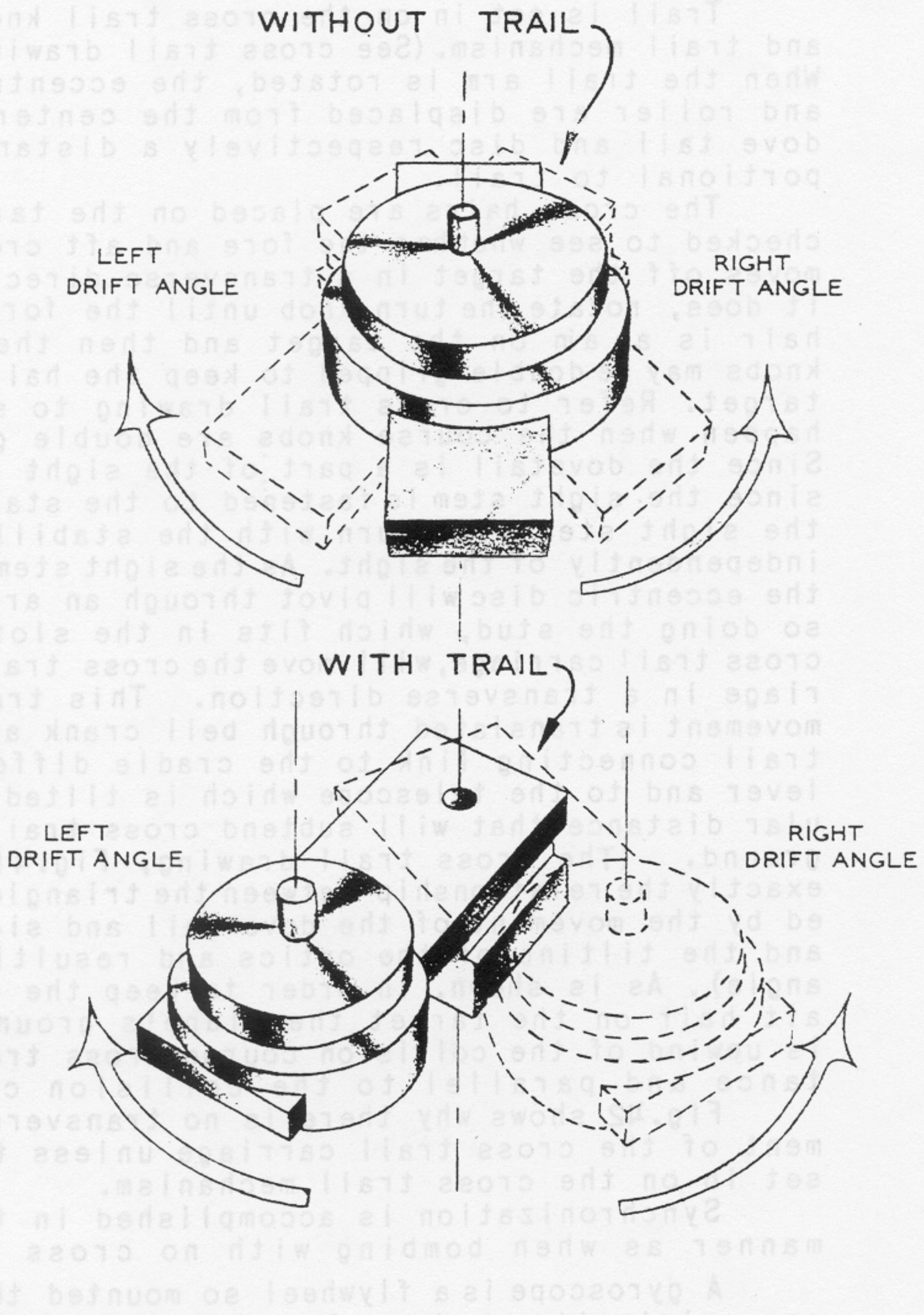


FIG. 42

concentric inner ring. This ring is free to revolve in pivot bearings in an outer ring, about an axis which is always at right angles to the axis of rotation of the wheel. The outer ring likewise is free to revolve in pivot bearings in a supporting frame about an axis which is always at right angles to the axis of rotation of the inner ring. With a universal mounting such as this, the axis of the wheel may be pointed in any direction by the touch of the finger.

In the bombsight the movement of the gyro is limited by the construction of the sight. The reason for the limitation of gyro movements is because the purpose of the sight is accomplished without entire freedom of movement of the gyro. The inner gimbal ring is the housing which encloses the rotor; the second gimbal ring is the cardan, and the third gimbal ring is the sight case.

3. Characteristics of Gyros

All of the practical applications of gyroscopes are based upon two fundamental characteristics, namely, "Gyroscopic Inertia" and "Precession".

When a gyroscope is subjected to a couple or a force about an axis at right angles to its axis of rotation it resists that couple, and the degree of resistance is proportional to the velocity with which the gyro turns,or precesses, about a third axis which is called the axis of precession. The resistance continues until the gyro has precessed so that its plane of rotation coincides with the plane of applied couple or force. Then precession ceaees and with it all resistance to the applied couple.

Rigidity of plane and fixity in space are also characteristics of gyros.

4. Laws of Precession

Fig. 43

1. If a force is applied perpendicular to the plane of rotation of a spinning gyro, its spin axis will precess ninety degrees in the direction of rotation from the point of applied pressure.
2. If a torque is applied about one of the axes of a spinning gyro, its spin axis will tend to align itself with that axis, and in the direction of rotation.

A convenient way to remember the direction of precession is to regard the applied couple or torque as a push acting at a single point on the rim of a wheel. This point will not move in response

APPARENT EASTERLY PRECESSION AND NORTH HOOK

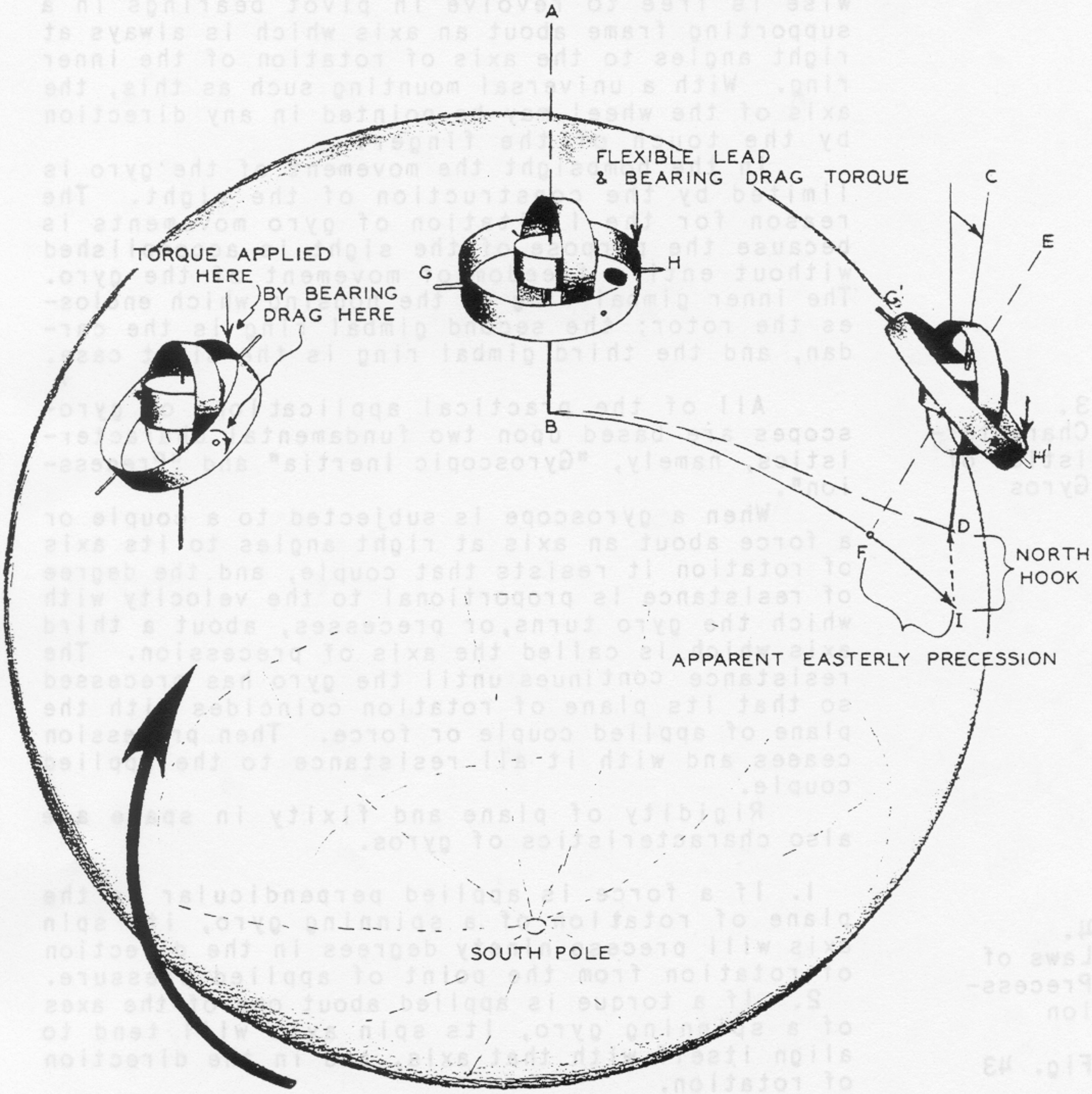


FIG. 43

to the push, but a point ninety degrees beyond in the direction of the wheel's rotation, will move away instead.

5.
Precession of Gyros.

In a previous lesson the kinds of precession were considered, and it is necessary to review them.

Technically there are two kinds of precession. They are: induced precession and apparent easterly precession. Induced precession is caused by a shifting of the weight mass of the gyro in relation to the spin axis of that gyro. A second type of induced precession, and precession over which the maintenance man has no control, is north hook, which is caused by bearing drag and flexible lead drag.

For purposes of study in this course only natural or apparent easterly precession will be considered. Just so long as the gyro behaves properly and gives a true precession in relation to the turning of the earth on its axis, it shall be satisfactory. In order to have normal apparent easterly precession it must be made certain that the gyro is so balanced as to eliminate all induced precession excepting bearing drag and flexible lead drag. It will be necessary to shift movable weights on the gyro housing in an effort to do this and leave only apparent easterly precession.

6.
Apparent Easterly Precession

Fig. 43

Easterly precession can be understood if one's thinking is based on the following three statements:

(a) The earth rotates from West to East, and requires 24 hours for a complete revolution of its 360° circumference.

(b) It is characteristic of a gyro for its spin axis to be parallel to its original position at any given moment of time.

(c) Gravity operates at all times to hold all bodies and things perpendicular to the earth.

In Fig. 43, the earth is shown rotating from west to east. AB represents the spin axis of the gyro at the beginning of a precession run. It has been erected to the vertical. CD represents the same spin axis about two hours later. Notice that the spin axis illustrated by CD is still parallel to the original starting position at AB, but is not in the true vertical in relation to the earth's surface when the earth has moved through the arc represented by the distance from B to I. To the observer it would appear that the spin axis had changed its position. Actually the rotation of the earth has caused the vertical to change relative to any point of reference, such as the vertical spin axis of the gyro. The observer does not sense this, and so it appears to him as though the bottom of the gyro's spin axis actually moved toward the east.

Linear Mil

A linear mil is an angle which from the vertical subtends 1/1000th of its altitude along its base line. Determine the linear distance subtended and then any angle, no matter how far from the vertical it may be formed, which subtends this same linear distance in the same problem is also a mil. Actually, the farther the angle proceeds away from the vertical, the smaller it must become to subtend the same linear distance.

To reiterate: In computing the amount of relative displacement of the gyro spin axis with the reference vertical (to the earth's surface) there are two units of measurement that can be considered. They are degrees and mils.

A degree is 1/360th of the circumference of a circle. A mil, for our purpose, is an angle that will subtend 1/1000th of its altitude along its base line.

Since the mil angle is determined from the vertical (that is a mil, is the angle formed from the vertical and which subtends 1/1000th of its altitude), then as each mil angle is formed farther from the vertical it becomes progressively smaller in order to subtend the fixed mil distance. Now it can be shown mathematically that the angular increase between the gyro spin axis and the vertical continues to increase at the same rate; that is, if it takes the spin axis 10 minutes to precess the first 4° from the vertical, it will take it 10 more minutes to precess 8° from the vertical. Then, the farther away the spin axis deviates from the vertical, the greater linear mil distance it precesses for any given period of time.

North Hook Fig.43

North hook is or can be caused by (1) flexible lead drag, (2) bearing drag, and (3) pendulousness of the vertical gyro. Notice Fig. 43 for position of the bearings.

AB represents the spin axis in the vertical position at the start of the precession run. Two hours later it is represented by CD. CD is no longer in the vertical. EF represents the vertical. If the outer gimbal ring is horizontal at the beginning of the run, it will naturally remain that way two hours later, when it is designated as G'H'. FI represents the amount of apparent easterly precession.

In the bombsight, the case and the cardan are not stabilized for lateral tilt, i.e. roll. Therefore, they are free, under any force to move independently of the gyro housing. Gravity is such a force, and it will force the right end of the case and cardan to move downward as the earth rotates (sight on North heading). This means the tilting will take place on the gyro gudgeon bearings. Since no bearing is absolutely frictionless, this tilting will exert a slight force upon the right face of the gyro housing tending to depress the right face downward. Under the laws of precession, the rear face will precess downward, thus moving the bottom of the spin axis to the north, i.e. north hook.

There are three flexible leads leading from the left end of the case to the left end of the cardan (two flexible leads in the M3) and three more leading from the front of the cardan to the front of the gyro housing. The latter three only will be concerned with the tilting in this problem. Since no lead is perfectly flexible, the tilting of the case and cardan to the right and downward will tend to exert a slight force upon the right face of the gyro housing. Thus, again we have north hook.

If the sight were placed upon a south heading, the considerations would be the same as the above, except that the tilting of the case and the cardan would take place in the opposite direction. Here the right end of the case and the cardan would move upward, and the left end downward.

If the sight were placed upon either an east or west heading, tilting would take place upon the cardan gudgeon bearings, since both the gyro housing and cardan are stabilized in the fore and aft plane, i.e. against pitch.

It should now be obvious why flexible lead drag, bearing drag, and pendulousness always, no matter on which heading, produce north hook. These elements, no matter on what heading, always produce a precessing force upon the east face of the gyro; this, considering the gyro rotates clockwise, causes the south face to precess downward, which in turn causes the bottom of the spin axis to move northward.

In checking the gyro for apparent easterly precession, use the formula 17.45 times the cosine of the latitude (taken from the trig. tables.) Likewise one must use the optics as a means of sighting for the precession, the optics being lined up with a grid plate which is calibrated according to dimensions in mils.

If the latitude is not known, so that apparent easterly precession can not be computed in mils, balance the gyro so that it precesses an equal amount on opposite headings. The same applies to north hook.

If the gyro precesses equally on all four headings, and the leveling bubbles do not move more than 1/4 a bubble length in two minutes from cen- of reference mark on bubble tube, the gyro is precessing correctly.

Why Sight, In Precession Run, Must Face Cardinal Heading.

Why must the sight, in making a precession run, face on a cardinal heading? There are three reasons: (1) in balancing the gyro statically while making a precession run, it would be necessary to shift about both sets of centering weights every time an adjustment was made if the sight did not face on a cardinal heading. This would make the adjustments extremely difficult. (2) The more the number of bearings the gyro requires to tilt as a result of easterly precession, the greater will be the amount of north hook. And if the sight were not on a cardinal heading, the gyro would tilt on the cardan gudgeon bearings, the gyro gudgeon bearings, and the telescope cradle gudgeon bearings. Standardized readings for north hook have been made only on cardinal headings and therefore we have no way of knowing what the correct amount or north hook shoud be other than a cardinal heading. (3) East is the direction of apparent easterly precession, and since east is itself a cardinal heading, it is logical that the sight face on a cardinal heading.

Theory of Static Balancing of Gyro.

First, multiplication of 17.45 mils by the cosine of the latitude will give the correct number of mils apparent easterly precession for four minutes. A close approximation of this figure on one cardinal heading should be sought. Then the sight should be faced upon the opposite cardinal heading. It may well be that the gyro will not give the same reading for apparent easterly precession on this heading. It is of no avail to try to force it. It should be recognized that because of some natural force, normally causing excessive north hook, the gyro will not, on these two headings, precess the computed distance. The principle now is to work on the opposite headings alternately until apparent easterly precession is equal on both. It will now doubtless be found that north hook does not equal the computed distance (three mils in four minutes at the Denver latitude,) but obviously the correct amount cannot be gained by attempting to rebalance; the trouble lies with flexible lead drag, bearing drag, or pendulousness or mechanical defect.

If north hook were excessive and it was found that there was excessive flexible lead drag, or bearing drag, or pendulousness, and the cause of the excessive flexible lead drag, or bearing drag, or pendulousness were removed, it would be found that (1) easterly precession (apparent) would increase to the stated mathematical amount and (2) that north hook would decrease to the stated amount

SECTION VII
DISASSEMBLY AND REASSEMBLY SIGHT

Bombsight maintenance personnel should always keep in mind one important maintenance principle. That is, that as long as the equipment is functioning perfectly there is no need for a partial or complete disassembly. Any complete disassembly should be done by men specifically trained for that job.

In the majority of cases, the maintenance man will have new equipment which is accurately calibrated. There are doubtless many instances in which the equipment arrives improperly calibrated. This should be checked for and any steps of calibration called for should be performed. Calibration, however, does not involve disassembly. Check should be made to see that the equipment is functioning properly, and if it is, do only the necessary maintenance required to maintain the efficient operation. That maintenance would consist of the inspections outlined in the C. L. I. and on the first page of the log book.

In the following section on disassembly and assembly no attempt is made to give complete disassembly, but rather that which is most frequently encountered by the maintenance personnel and the disassembly which is required in order to clean the parts of the sight most frequently requiring cleaning and lubricating for proper maintenance.

The outline of disassembly procedure is not the only means of disassembly, but is one which has been used and which has proved to be satisfactory. This procedure is to be used as a guide and is not to be memorized. The maintenance man should be so thoroughly familiar with the equipment that the correct disassembly and assembly procedure will be automatic. An orderly procedure will prevent damage to the equipment and will save precious minutes.

Always remember that the bombsight equipment is precision made and that parts are never to be forced. If, at any time, trouble is encountered, always contact your superior, and in the absence of the proper superior use your head and reason out the solution.

BOMB SIGHT ASSEMBLIES

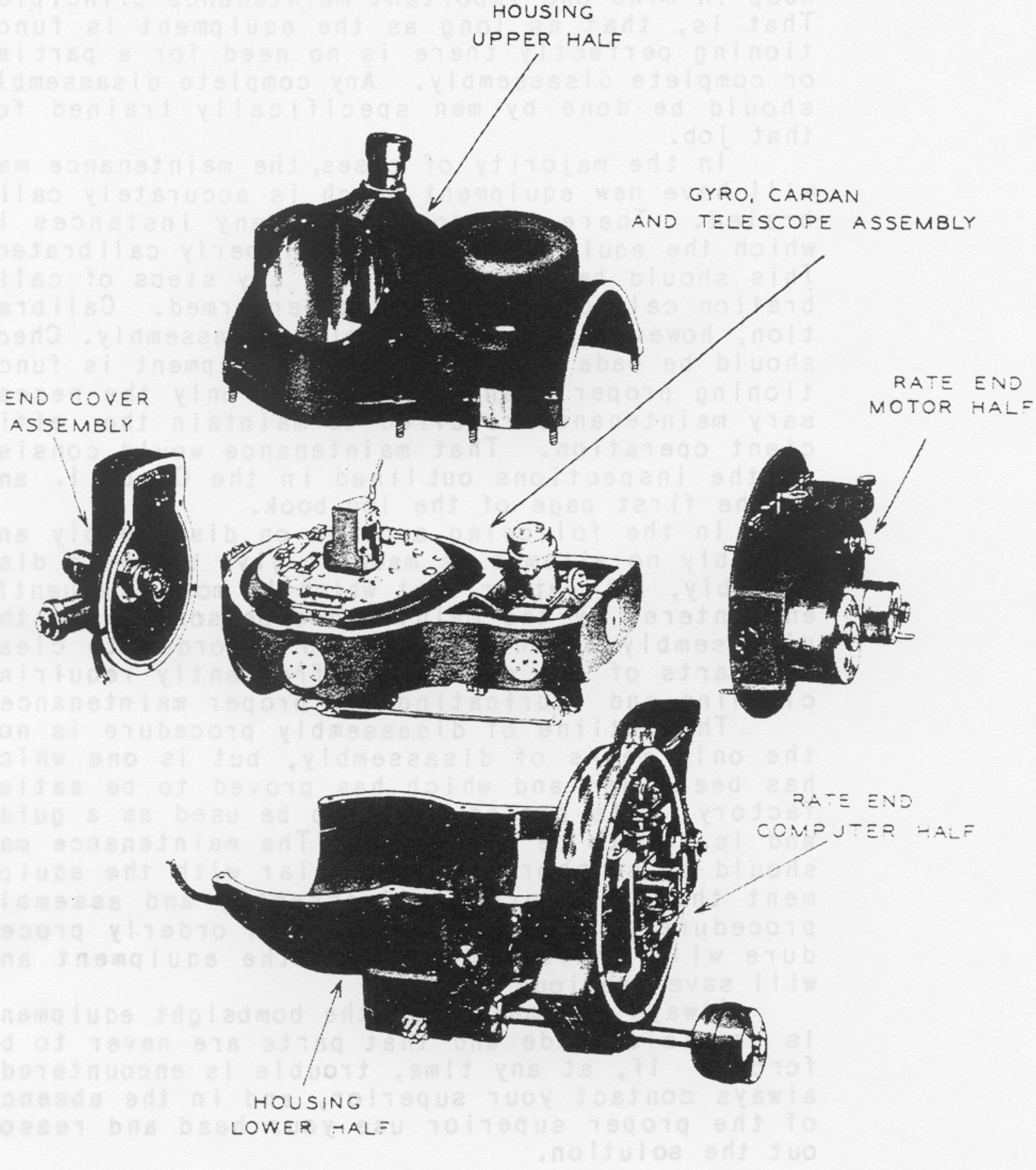


FIG. 44

DISASSEMBLY AND ASSEMBLY

DISASSEMBLY

A	Housing Upper Half	1. Remove upper housing screws in housing, 2 screws in end cover. Rotate trail arm toward maximum before removing housing of M-6. 2. Clean gyro inspection window and telescope window (M-3). Check before replacing housing. Clean the eye piece (M-6). 3. Set housing aside.
B	Rate End - Motor Half	1. Remove 5 screws holding motor half of rate end to case. 2. In the M-6 remove the pin connecting the bell crank to the cross trail rack before removing the 5 screws. 3. When removing the motor half of the rate end work loose from dowel pin at the top, tilt out and down to clear gears and then lift up so as to clear the course knobs and to prevent damage to the gears. Place aside for later disassembly.
C	Telescope Cable	1. Set telescope quadrant at maximum sighting angle. This removes the tension that the mirror return spring applies to the cable. 2. Loosen the anchor screw and remove cable from the number 1 sheave. 3. With an orange stick pull the cable through the right cardan gudgeon bearing. 4. Remove taper pin from No. 5 sheave. a. Remove sheave. b. Loosen anchor screws and remove cable from No. 5 sheave. c. Care should be used in removing bronze cable so as not to fray or kink it.
D	No. 3 Sheave	1. Remove two screws holding yoke and lift out yoke and sheave.
E	Cardan Locking Nut	1. Remove right cardan gudgeon locking nut with 3/8 wrench furnished for that purpose.
F	End Cover	1. Remove the three flexible leads from the end cover to the cardan at the cardan. 2. Drive fiber wedges between the cardan and case

to support the cardan, or remove locking screws in the gyro gudgeon bearing and insert steel punches to support the weight of the cardan.
3. Loosen brackets holding wire to case of M-6 so that end cover may be removed.
4. Remove the three screws in end cover and remove cover.

CAUTION: Do not damage left cardan gudgeon bearing.

G. Cardan

1. Set maximum trail on cross trail knob, and rotate sight stem counter-clockwise.
2. Lift cardan from gyro end and tilt forward and remove by slight movement to the left and up. Be careful not to damage the right cardan gudgeon bearing.

    It is possible to remove the cardan and end cover at the same time. To do that the three end cover screws are removed and then the cardan is grasped with right hand and tilted forward. The left hand is placed around the end cover and under the leveling knobs. Lift up and to the left and remove cardan and then remove the end cover.
3. Always stand the cardan on end or place on table with the back edge of cardan resting on the table. Care must be exercised not to damage the connecting rod and the mirror.

REASSEMBLY

A. Cardan

1. Hold cardan in both hands and place right cardan gudgeon bearing over the gudgeon.
2. Check to make sure that the bell crank is properly seated in the C.T. carriage fork.
3. Hold cardan and insert wedges between cardan and case.

B. End Cover

1. Replace end cover. Be certain that left cardan gudgeon bearing is properly seated.
2. Replace 3 lower end cover screws.
3. Place wire under brackets and tighten screws.
4. Replace flexible leads and reshape. The leads should be " S " shape and should not touch each other or the case or bail as the cardan is tilted fore and aft.

C. Cardan Locking Nut

1. Replace and tighten right cardan gudgeon locking nut with 3/8" wrench.
2. Tilt cardan fore and aft to check for freedom of movement.

D. No. 3 Sheave	1. Replace number 3 sheave and yoke.
E. Telescope Cable.	1. See page 75 for installation of telescope cable M-3. 2. See page 157 for installation of telescope cable M-4 and up.
F. Rate End Motor Half	1. Tilt top of rate end out and place lower side back of the course knobs. 2. Fit over dowel pin. a. Be careful not to jam disc against roller carriage. b. Be sure that the armature windings of telescope motor are not damaged by the intermediate gear. 3. Rotate rate and displacement knobs, search knob and forward view mechanism (M-6) to see that all gears are properly meshed. 4. Motor half should fit snugly against housing of computer half. If it does not, recheck your work. 5. Replace screws. Tighten snugly. 6. Replace pin connecting bell crank and cross trail rack.
G. Housing Upper Half	1. Replace housing. 2. Insert and tighten screws. 3. Rotate trail arm to minimum on M-6. 4. Check and clean glassware if necessary.

SECTION VIII

DISASSEMBLY AND REASSEMBLY OF ASSEMBLIES, SIGHT

DISASSEMBLY AND REASSEMBLY

RATE END (MOTOR HALF)

A. Rate and Displacement Knobs.

Fig. 34

A. Disassembly

1. Remove three screws fastening rate and displacement knob mounting plate to housing and remove housing.
2. Tap taper pin from displacement clutch knob, and remove knob.
3. Remove two screws and remove displacement knob.
4. Remove gear shift fork. (M-6)
5. Remove displacement knob shaft and displacement clutch shaft.
6. Remove gear plate.
7. Remove set screw from rate knob and remove gear.
8. Clean all parts; oil with film of light oil and reassemble.

B. Reassembly

1. Replace rate intermediate gear and set screw.
2. Replace gear plate.
3. Replace displacement clutch shaft and pin and displacement knob shaft.
4. Replace displacement knob.
5. Place displacement clutch knob on shaft and insert taper pin.
6. While gear shift fork is removed, clean and oil slides and replace fork. (M-6)

B. Altitude Knob.

Fig 32

A. Disassembly

1. Rotate lock knob until flat surfaces of cam clear retainer screws.
2. Pull calibrated knob off.
3. Remove screw and washer holding low altitude clutch holder in place.
4. Loosen 3 set screws in spring case and remove case and spring.

MOTOR HALF RATE END DISASSEMBLY

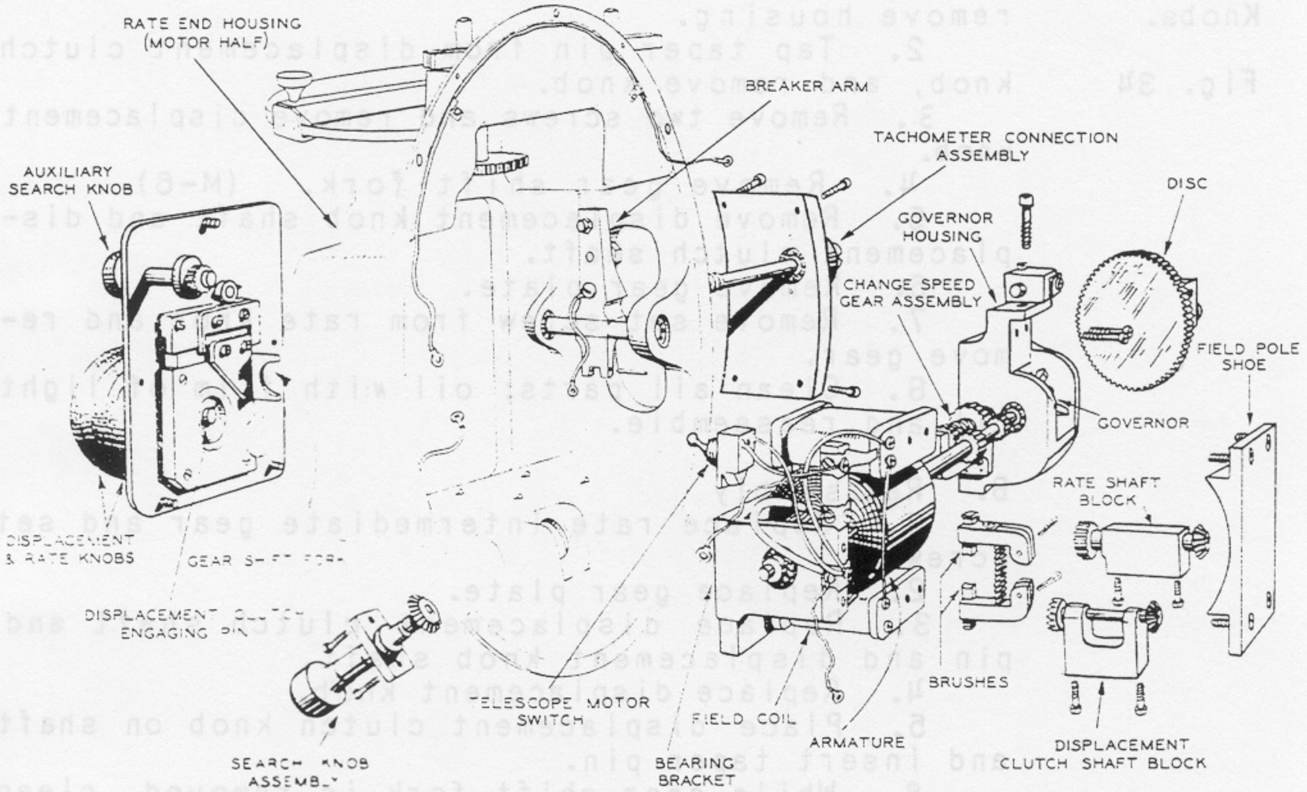


FIG. 45

CAUTION: Tap case with fiber drift and mallet if case is hard to remove. Rotate case so as to remove evenly. The spring clutch holder may stick to the shaft. Check so the holder will free shaft at same time the case comes off. This will prevent damage to the spring.

5. Remove washer.
6. Tap taper pin from high altitude spring clutch holder.
7. Loosen 3 set screws and remove case and spring.
8. Remove 3 screws holding fiber friction ring and adjusting springs.
9. Remove friction collar.
10. Remove altitude knob flange.
11. Clean all parts and lubricate with film of light oil.
12. Oil bearings with one drop of light bombsight oil every 50 hours.

CAUTION: Do not oil the fiber friction ring nor the metal collar which it engages.

B. Reassembly.

1. Replace altitude knob flange.
2. Friction collar stop.
3. Friction ring.
4. Adjusting spring (Flat brake spring)
5. Replace high altitude spring and case.
6. Replace taper pin in spring clutch holder.
7. Replace washer.
8. Replace low altitude spring and case.
9. Replace screw and washer holding low altitude spring clutch holder in place.
10. Adjust for correct speeds and replace calibrated knob.
11. Calibrate knob as per C.L.I. B-43-5.

C. Search Knob

A. Disassembly and Reassembly.

1. Remove from case, 2 screws.
2. If dirty or shaft is binding.
   a. Tap out taper pin, remove pinion and shaft.
   b. Clean, lubricate with film of light oil and reassemble.

D. Rate and Displacement Pinion Shaft Blocks (M-6)

A. Disassembly and Reassembly

1. Remove from case, 2 screws for each block.
2. If shafts bind.
   a. Tap out taper pins, remove pinions and shafts, clean with benzine or carbon tet., lubricate with film of light oil and reassemble.

E. Tachometer Connection

No disassembly is necessary; however, the assembly must be removed in order to remove the disc assembly without overcoming the tension of the thrust spring

Four screws hold the mounting bracket to the sight case.

F. Disc assembly

A. Disassembly

1. Remove disc shaft bearing block, 2 screws and a hexagon bolt. Watch for shim.
2. Tap taper pin from shaft and collar.
3. Remove disc shaft from block.
4. Clean all parts with carbon tet. Wipe dry with clean white cloth and lubricate with film of light oil.

CAUTION: Never use an abrasive on the disc. Oil with film of oil and wipe off all excess oil.

B. Reassembly

1. Place bearing block on shaft.
2. Replace collar and taper pin.
3. Replace block. If a shim is used be certain that it is replaced exactly as it was before removal. Tighten screws and bolt.

G. Telescope Motor

Fig. 45

A. Disassembly

1. Remove armature block (Field pole shoe).
2. Remove (from outside of case) 2 screws holding bearing block, commutator end, and 2 screws holding field coils.
3. Remove telescope motor brushes.
4. Remove straight pin from governor connecting rod and breaker arm (governor control contact shaft lever).
5. Remove 4 screws holding governor housing.
6. Lift out assembly.
7. Tap straight pin from motor armature shaft and governor fork.
8. Remove gear, change speed gear mounting bracket, 2 screws (M-6).

9. Remove bearing bracket, commutator end.

10. Remove motor armature shaft from bearing in governor housing.

11. If governor is dirty remove governor housing cap, governor sleeve guide and pins in linkage and clean.

12. Remove bearing from governor housing.

13. Clean bearings if dirty and oil with 2 or 3 drops of light bombsight oil. One drop, if bearings were not cleaned but are dry.

14. Clean all parts and lubricate governor with minute amount of light bombsight oil.

B. Reassembly

1. Replace armature shaft bearing in governor housing.

2. Reassemble governor linkage; replace housing cap, 4 screws, and governor sleeve guide 3 screws.

3. Replace armature shaft in bearing.

4. Replace bearing bracket commutator end.

5. Replace gear change speed gear mounting bracket (M-6).

6. Replace field coils.

7. Insert straight pin in armature shaft and governor fork.

8. Replace assembly in housing, 6 screws.

9. Replace telescope motor brushes.

10. Insert straight pin in governor connecting rod and breaker arm.

Rate End
Computer
Half

It is not necessary to disassemble the computer half of the rate end to perform maintenance. The only part of the rate end (computer half) that needs to be removed to clean is the bearing in the roller. NEVER REMOVE UNLESS NECESSARY.

Fig. 33
pg. 68

A. Disassembly

1. Remove 2 screws (M-3), 4 screws (M-6) and remove extension pinion bracket.

2. Remove roller and bearing.

CAUTION: care must be exercised or carriage and roller will be damaged.

Fig. 34
pg. 70

3. Clean bearing with benzine or alcohol and and oil with one or two drops of light bombsight oil. This bearing must be perfectly clean or erratic roller speed will result.

B. Reassembly
1. Replace bearing.
2. Replace bearing on stud.
3. Replace bracket.
4. Rotate bearing and check for binding.
5. Replace screws and check again for freedom of roller movement. There must be no binding. Do not force a part into place.

Cross Trail Carriage

A. Disassembly
1. Remove 4 guides, 2 screws each.
2. Lift out cross trail carriage.
3. Clean slides with carbon tet., alcohol or benzine, wipe dry with clean cloth and lubricate with light film of lightweight bombsight oil. (Fig. 35 pg. 76)
NOTE: There are two slides in M-6.

B. Reassembly.
NOTE: If complete disassembly of sight is being done, do not reassemble cross trail carriage until the sight stem has been reinstalled.
1. Replace cross trail carriage.
2. Replace slides and tighten screw firmly and evenly.
3. Slide C.T carriage back and forth. There should be no binding. If C.T. carriage slides hard, check for dirt or tension of slides on the C.T. carriage.

Cross Trail Knob M-3

This assembly requires very little attention and is found only in M-3 and earlier models

A. Disassembly.
1. Tap taper pin from cross trail knob, remove knob.
2. Remove screw and remove yoke and actuating shaft.

B. Reassembly.
1. Replace yoke, actuating shaft and screw.
2. Replace cross trail knob and taper pin.

Cross Trail Operating Mechanism M-6

A. Disassembly.

1. Remove guide stud.
2. Remove guide link.
3. Remove guide.
4. Remove bell crank brackets, 4 screws.
5. Remove bell crank and cross trail push rod.
6. Clean with carbon tet., alcohol or benzine, wipe dry with clean white cloth and lubricate with film of light bombsight oil.

B. Reassembly.

1. Insert C.T. push rod into push rod guide bracket.
2. Replace bell crank brackets, 4 screws.
3. Replace guide.
4. Replace guide link.
5. Replace guide stud.
6. Check for freedom of movement.

Stabilized Sector and Sight Stem Assembly M-3 and M-6

Fig. 31 pg. 64

A. Disassembly.

1. Remove 6 screws from sight stem flange and remove sight stem bushing, sight stem, dovetail, eccentric disc, stabilized sector, and stem thrust washer.
2. Remove eccentric disc.
3. To remove sight stem from bushing, tap taper pin from cross trail locking sleeve and pull stem from bushing.
4. Clean all parts and lubricate with film of light bombsight oil.

   CAUTION: Do not drop eccentric disc nor damage dovetail.
5. In the M-6 series the two taper pins in the cross trail locking sleeve must be removed.
   a. Pull sight stem up and out before removing 6 screws holding sight stem bushing to the housing. The elongated dove tail on the M-6 sight stem will not clear the opening in the sight housing.

B. Reassembly.

1. Replace sight stem in bushing.
2. Place stabilized sector on sight stem bushing.
3. Replace stem thrust washer.
4. Insert sight stem and replace 6 screws.
5. Replace eccentric. Be sure that the stud is toward the rear. (M-3)
6. The sightstem bushing must be reinstalled in M-6 before the sight stem is replaced.

Leveling Knobs M-3 M-6

A. Disassembly.

1. Remove taper pin.
2. Press on knob to prevent spring from releasing when taper pin is removed.
3. There are two turn knobs on the M-6 and two springs.
4. Clean, oil and reassemble.

Remove Gyro from Cardan M-3 and M-6

If the vertical gyro gudgeon bearing becomes dirty, the gyro must be removed and bearing cleaned. The bearing can be inspected for oil by removing the gudgeons. The gyro should not be removed from the cardan unless necessary. Ordinary maintenance does not require removal of gyro or cardan.

A. Disassembly.

1. Remove telescope cradle connecting rod.
    a. Loosen screw through lever link retainer and disengage retainer and connecting rod stud. Do notbend retainer.
2. Remove 2 (M-3), 3 (M-6) flexible leads from gyro to cardan at gyro connection.
3. Remove 2 flexible leads, to bail locking magnet, at cardan connect. (M-6)
4. Remove bail locking bracket 2 screws (M-6).
5. Remove bail, 4 screws (M-6).

6. Remove locking screws from gyro gudgeons.

7. Remove gudgeons, use gudgeon screws in puller arrangement and support gyro with hand to prevent binding of gudgeons.

8. Tilt gyro and cardan and with hand under gyro lift up. Then grasp gyro with other hand and and lift gyro clear of cardan.

9. If gudgeon bearings are dirty, clean and lubricate with one or two drops of light bombsight oil.

CAUTION: Be certain that the gudgeon bearings are replaced in the same position as before removal. The locked bearing is to the rear.

10. If commutator is dirty, remove the brushes before cleaning commutator.

11. If brushes are to be removed:
   a. Remove terminal screw connecting pig tail to brush holder.
   b. Measure the distance the brush plug extends from the holder and scribe the plug so that it may be reinstalled to its original position.
   c. Clean the brushes with alcohol or carbon tet. and check for contact.
   d. Clean commutator and brush tubes.
   e. Reinstall brushes and connect terminals.

B. Reassembly.

1. Replace the gyro gudgeon bearings.

2. Grasp gyro firmly and lower into place in the cardan.

3. While holding gyro align the rear gudgeon bearing and the gudgeon hole in the rear of the cardan.
   a. Insert gudgeon pin. If the bearing is not exactly aligned the gudgeon will not fit into the bearing. Work gudgeon with fingers until the flange of the gudgeon is in place. **NEVER FORCE A GUDGEON INTO PLACE. THIS WILL BURR THE GUDGEON AND THE BEARING LOCK PLUG.**
   b. Replace front gudgeon and tilt gyro to check for freedom of movement. With cardan nearly level and gyro approximately vertical tap gyro. It should tilt easily and freely to either side.

c. Replace rear gudgeon locking screw first and tighten; then replace front gudgeon locking screw and tighten.
d. Replace other gudgeon screws and again check for freedom of movement of gyro. NEVER INTERCHANGE GUDGEON SCREWS OR LOCKING SCREWS.

4. Reinstall bail and bail locking bracket.

5. Connect flexible leads, 2 from bail, 3 from cardan to gyro (M-6). On M-3 connect 2 flexible leads from cardan to gyro.

6. Reinstall telescope cradle connecting rod.

7. Check for balance of cardan and gyro. Cardan should tilt slightly to the rear when gyro is cold.

Removal of Cradle from Cardan

Fig. 37
Pg 82

If the double cable breaks the cradle must be removed from the cardan to install the double cable.

A. Removal.

1. Remove telescope cable.

2. Remove #3 and #4 sheaves and pins.

3. Disconnect telescope cradle connecting rod at differential lever.

4. Disconnect cross trail connecting link at cross trail lever clamp.

5. Remove gudgeons and lift cradle from cardan.

6. For installation of double cable see Section IX, page 173.

7. Always check gudgeon bearings for oil and dirt when cradle is removed. The same care must be exercised in cleaning and installation of cradle gudgeon bearings as in the vertical gyro.

B. Replace cradle.

1. Place cradle in cardan.

2. Hold cradle and align bearings with gudgeons as gudgeons are inserted.

3. Check to see that gudgeons do not bind

4. Connect cross trail connecting link.

5. Connect telescope cradle connecting rod.

6. Reinstall # 3 and 4 sheaves and pins.

7. Install telescope cable.

Gyro Locking Knob

A. Disassembly.

1. Remove gyro locking knob retainer screw.
2. Remove locking knob.
3. Remove locking spring.
4. Remove locking cone.
5. Remove locking knob sleeve, 4 screws.
6. Clean and lubricate with film of light oil.

B. Reassembly.

1. Replace locking knob sleeve.
2. Replace locking cone.
3. Install locking spring.
4. Replace locking knob.
5. Insert gyro locking knob retainer screw.

Telescope Cross Hair Light

A. Disassembly.

1. Remove 2 screws (M-3) 4 screws (M-6) and remove housing.
2. Check action of switch, clean working parts.
3. Check illuminating mirror in M-6 for brightness and dust.
4. To remove bulbs in M-3 remove two screws in base of socket and remove socket, then unscrew bulb. The bulb and switch are fastened to the removable housing in M-3.

On the M-6 the bulb and rheostat are mounted on a mounting bracket attached to the sight case with 4 screws. This mounting bracket need not be removed.

To remove the bulb in the M-6 push down and turn clockwise to release the bayonetfrom the notch. Push down and turn counter clockwise to install bulb.

B. Reassembly.

1. Replace housings.
2. Check operation.

Course
Knobs
M-3
M-6

Fig. 31
pg. 64

A. Disassembly.
  1. Remove assembly from sight case, 7 screws. Check for shims.
  2. Remove locking nuts and spring (M-6).
  3. Remove turn worm, shaft bearing, 4 screws.
  4. Remove cover from intermediate gear housing, 2 screws.
  5. Remove taper pin in turn knob and remove knob.
  6. Remove turn worm and shaft.
     a. Turn worm need not be removed from shaft.
  7. Clean all parts thoroughly and lubricate.

B. Reassembly
  1. Replace turn worm and shaft.
  2. Replace turn knob and taper pin.
  3. Replace intermediate gear housing cover, 2 screws.
  4. Replace turn worm shaft bearing, 4 screws.
  5. Replace locking nuts and spring (M-6).
     a. Turn nuts down and then back off 1/2 a revolution. This should give .003" end play. (M-6).
     b. When replacing course knob assembly there should be no play or binding between turn worm and stabilized sector. If the turn worm binds, shim between the course knob assembly and the sight case.
        1. Shim and remove .001" at a time until proper clearance is obtained.
        2. Shim, also between the shaft bracket and the rate end housing. The shims between the bracket and case must be the same thickness as those between the case and the turn worm housing or the drift shaft will bind.
     c. If there is play or binding between the drift worm and the drift, loosen the screw in the intermediate gear housing and position drift worm and housing until the play or binding is eliminated.

SECTION IX

MAINTENANCE, SIGHT

GENERAL

A. Purpose.

Proper maintenance of the bombsight is necessary if it is to function properly.

B. Definition.

Maintenance may be defined as the proper care of tools and equipment to insure maximum efficiency and long life.

The three most important items of maintenance are to keep the bombsight: 1. Clear; 2. Dry; 3. Properly lubricated.

C. Handling-- N.O.P. #650, p.6. C.L.I. C-43-14

Bombsight equipment is very delicate and it must be protected from blows and rough handling. Great care must be exercised so as not to drop the equipment. Such an occurence will ruin a sight or stabilizer or will require extensive repairs at high cost and will necessitate withdrawal of the unit from service until such repairs can be made. The following precautions regarding handling of bombsights and stabilizers must be rigorously adhered to:

a. No man will carry more than one piece, bombsight or stabilizer, at one time.
b. There is always some danger in transfering the equipment in and out of planes, where footing is precarious. Here special care must be taken and the man receiving the unit must have a firm hold before the other lets go, if two men handle the unit.
c. Any undue shock or jar may damage the bearings thereby upsetting the delicate balance of these instruments.

D. Log Books N.O.P. #650.

The log book shall be studied by the student at the beginning of each session of the class. At the close of each session of the class, proper entry shall be made in the log book by the student. and under the supervision of the instructor. Running time entries will be to the nearest five minutes.

The Bombsight Log is an official history of the bombsight from the time of its manufacture until it is withdrawn from service for survey. It is an official document and must be treated with the same care when making entries as any other log book. All entries except class room instruction will be signed by a BSM officer.

The log book is self-explanatory so far as entries are concerned, and no difficulty should be experienced in keeping it. It has been found from examination of log books which have been turned in with instruments for repair and overhaul that:

(a) A great deal of work is done on bombsights which is not entered in the log.

(b) Considerable maintenance work is performed by inexperienced personnel.

(c) There is a tendency to perform more disassembly and adjustment than is necessary.

In order that the overhaul personnel may have a full knowledge of the condition of the equipment it is of the utmost importance that every adjustment or casualty be recorded clearly and fully in the log. It is only by cataloguing the frequency of casualties and adjustments that it is possible for personnel charged with design to have an indication of desired or necessary changes and be able to take steps to correct current designs, or instructions.

Whenever a bombsight is withdrawn from the service and turned in to the Supply Officer for storage or shipment, a notation will be made by the bombsight officer concerned as to the exact condition of the equipment. This notation will be made immediately following the last previous entry in the log book and will, in general, include the following information as applicable for guidence of the Supply Officer and others concerned.

(a) This bombsight and/or stabilizer is in serviceable condition for reissue without repair.

(b) This bombsight and/or stabilizer should be forwarded to an overhaul shop for repair or overhaul prior to reissue.

(c) This bombsight and/or stabilizer has been lubricated and otherwise prepared for temporary storage.

(d) This bombsight and/or stabiliz- has been lubricated and other -

wise prepared for extended storage.

Whenever either the bombsight or stabilizer is turned in for overhaul or repair the log book must be forwarded with it. It must be in order and and up to date.

In order to indicate to the shop receiving a serviceable sight whether it has received any damage during shipment, the last precession chart accomplished should be inserted in the log book.

E. Over-night Settings

A. Stabilizer
1. Engage clutches.
2. Fasten to carrying stand.
3. Close vent.
4. All switches "off".

B. Sight.
1. Cage gyro.
2. Set stabilized sector arm under sight with bombsight connecting rod pin in sector. (M-3 and M-6). Later modified units have pin attached to bombsight connecting rod.
3. Set trail arm at zero.
4. Set rate indicator off zero.
5. Set telescope to maximum sighting angle.
6. Set altitude knob at high altitude (minimum stop.)
7. Raise prism (M-3).
8. Close vents (M-3).
9. All switches "off".
10. Fasten sight to carrying stand.
11. Clutch in telescope clutch.

F. Inspections N.O.P. #650

1. Pre-Flight Inspection.

This inspection shall be performed **EACH DAY** at the beginning of **EACH SHIFT**.

Only ten (10) or fifteen (15) minutes are required to make the pre-flight inspection on both sight and stabilizer, if the maintenance man is thoroughly familiar with the inspection.

I. Sight Pre-Flight Inspection

The following procedure should be followed in making a pre-flight inspection of the sight. If sight is mounted on the stabilizer, test P.D.I. action. If the sight is mounted on the carrying stand the P.D.I. cannot be checked.

1. Check the log book for imminence of periodic inspection and lubrication. (50 hour inspection and 15 hour and 15 day lubrication inspection.)

2. Turn on the bombsight switch.
   a. Run sight gyro.
   b. Check coincidence of telescope pointers.
   c. Test search knob action.
   d. Test P.D.I. action. (See introductory paragraph).
   e. Test action of telescope drive clutch.
   f. Uncage the gyro and test action of the leveling knobs.
   g. Test automatic release.
   h. Check altitude knob for correct functioning and governing action at high and low speeds for each position of the disc speed change lever.
   i. Check fit of sight stem and locking pin.
   j. Check the bubble and telescope cross hair lights. Check action of cross hair lighting rheostat.
   k. Test action of increased forward vision knobs.
   l. Clean glass plates. Visually check internal condition of units.

For stabilizer pre-flight see page 39.

2. Daily Inspection

1. A stabilizer rotor bearing will be checked for oil daily if the unit is exposed to the hot sun or the unit is installed in an airplane which has been sitting in the hot sun for a period of two hours or more. Do not oil excessively.

2. Turn on all switches. Check operation of all moving parts.

CHECK VOLTAGE EACH TIME SIGHT IS USED

CAUTION: Always run gyro about 10 minutes and clean commutator, brushes after oiling rotor bearings.

3. 15 Hour and 15 Day Inspection C.L.I. 42-26 Log Book, Page 1.

15 HOUR INSPECTION:

1. Visual inspection of case.

2. Check wiring for frayed insulation, loose terminals and connections.

3. Check clutches for tensions and operation. Clean if necessary:
   a. Bombsight - 18-24 lbs.
   b. Auto-pilot - 10-12 lbs.
   c. Drift clutch - 6-8 lbs.

4. Check for oiling and corrosion. If gyro

rotor bearings are lubricated, run gyro for 10 minutes, remove brushes and clean commutator, brushes and brush tubes with carbon tet. Wipe with clean white dry cloth.

5. Inspect gears for burrs and dirt.
6. Check isolated sector and contact made by stabilizer brush.
7. Check slip rings for pits and contact of slip ring brushes.
8. Check telescope light.
9. Check action of all moving parts.
10. Clean glass.
11. Clean disc and roller.
12. Check disc speed.
13. If, during check, there is indication of malfunctioning, find trouble and correct.

If a 15 hour inspection is performed, the accumulated number of hours for the next 15 hours and the accumulated number of days for the next 15 day inspection will be dropped and started from zero.

15 DAY INSPECTION:

Inspect gyro rotor bearings each 15 days when gyro has been operated less than 15 hours in 15 days, Oil if necessary. Run all motors for 15 minutes whether lubricated or not. If gyro rotor bearings were lubricated, clean commutator, brushes and brush tubes.

Inspect for corrosion (exterior and interior).

If a 15 day inspection is performed, the accumulated number of **DAYS ONLY** for the 15 day inspection will be dropped and started from zero. A 15 day inspection **DOES NOT** cancel a 15 hour inspection.

4. Fifty Hour Inspection, Sight.

a. Sight Case or Housing.

1. The case must be kept clean and dry to prevent corrosion. Check condition of paint as to peeling, chipping, etc. If the paint has been chipped or has peeled but no corrosion formed, scrape and polish the area with a hard wooden stick and crocus cloth and retouch with a fast drying crackle finish lacquer on the exterior, and black mat varnish on the interior. If the corrosion has formed underneath paint, scrape and polish the area thoroughly before retouching. Corrosion of the magnesium alloy in the equipment may be detected as a white powder or paste similar to the the substance which is found on a "dead" dry cell

battery. It must be removed completely by scraping it away to the bare metal. Retouch with lacquer or varnish. Rub in a small amount of bombsight oil as an emergency measure if lacquer or varnish is not available.

2. Check for corrosion around screw heads. If corrosion is found it is the case, not the screw, that is corroded. All screws are either brass or stainless steel. Too much emphasis cannot be put on the fact that most screws are small, soft, and the threads are delicate, both on the screw and in the hole. Always remember that you are working on an extremely delicate instrument. To avoid corrosion of screw holes, dip each screw in light oil before replacing.

DO NOT DIP THE SCREW IN YOUR MOUTH!

3. If the case is dented or cracked to such an extent that the operation of any unit is impaired, the condition should be reported to the Chief A.F. Maintenance Command and method of disposition requested.

4. Remove dirt from interior of case with alcohol moistened cotton on a swab stick. **NEVER TRY TO BLOW THE DUST AND DIRT FROM THE INSIDE OF THE CASE.**

5. Check for corrosion and rust on the bare metal. Remove condition with acid-free kerosene and crocus cloth. Clean the surface thoroughly with benzine and dry with a clean white cloth. Use of clean white cloths in connection with this equipment is stressed, due to the fact that the dyes from colored cloth may easily be deposited upon the surfaces with which it comes in contact when used in conjunction with oil, solvents, etc., and create a dangerous chemical reaction.

b. Electrical Wiring Sight

1. Check for frayed or burned insulation, faulty terminals, and replace damaged parts, first remedying the cause of the trouble.

2. Check terminal screws for tightness, stripped threads and bad screwdriver slots. Replace where necessary.

3. Check for proper shaping of all wiring. This includes pigtails and flexible leads. The flexible leads from the case to the cardan are S shape and the leads from the cardan to the gyro are S shape when there are three and heart shaped when there are two. The leads must be shaped so that they do not touch each other or any part of the sight except at the connections. If the flexible leads are touching each other or the metal of

the sight there is danger or burning out the leads, and will cause precession.

The pig tails are shaped so that they enter the brush plug at 180° angle. This permits the brush to adjust itself to the commutator and prevents the pig tail from binding on the brush plug. The pig tail is curved from the brush plug to the terminal in such a manner that it will not touch anything as the gyro precesses.

4. Check continuity of all units through switch panel.

   a. Mount stabilizer and sight on the stand.
   b. Plug in the bombsight.
   c. Contact plus and minus terminals in stabilizer cannon plug, poles 2 and 1 respectively. With the prods of the ohmmeter set on poles 1 and 2, turn on one switch at a time and note the resistance in ohms for each circuit. **DO NOT HAVE CURRENT OF THE EQUIPMENT WHILE USING THE OHMMETER TO CHECK RESISTANCE.**
   d. Compare the reading obtained with the chart given. Not enough resistance denotes a short circuit; too much resistance indicates faulty connecttions, dirty terminals, loose terminals and, in some instances, broken wires making partial connection.

c. Average Resistance Chart, M-3 Sight.

	SWITCH POSITIONS AND TERMINALS CONTACTED.	AVERAGE
1.	B.S. switch "on", all other switches "off" and telescope light at minimum. Contact poles #1 and #2.	4 ohms
2.	B.S. switch and bubble light switch "on". Contact poles #1 and #2.	3 ohms
3.	B.S. bubble light "on", telescope light at maximum. Contact poles #1 and #2..	3.5 ohms
4.	Match telescope quadrant and rate quadrant indices, raise trigger and contact poles #3 and #4 in 6 pole plug.	0 ohms.

M-6 Sight

1.	B.S. switch "on". Contact poles #15 and#13.	12 ohms
2.	B.S. switch and telescope loght "on". Contact poles #13 and #15.	10 ohms
3.	Match telescope quadrant and rate quadrant indices and raise trigger. Contact poles #6 and #7. If re-	

STONING A GEAR

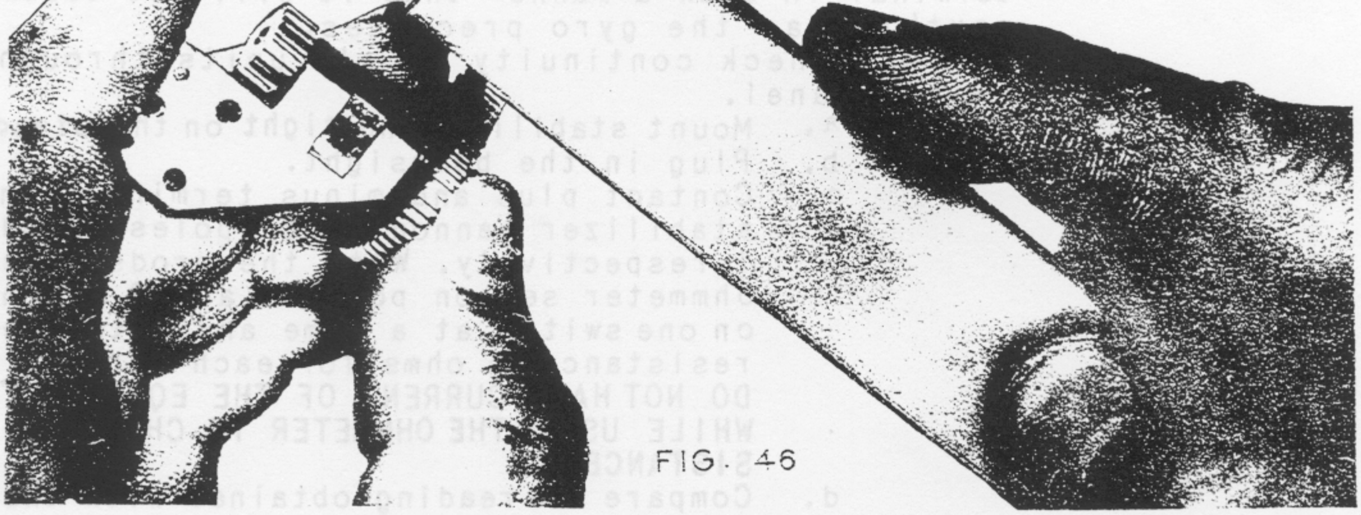


FIG. 46

CLEANING GEARS

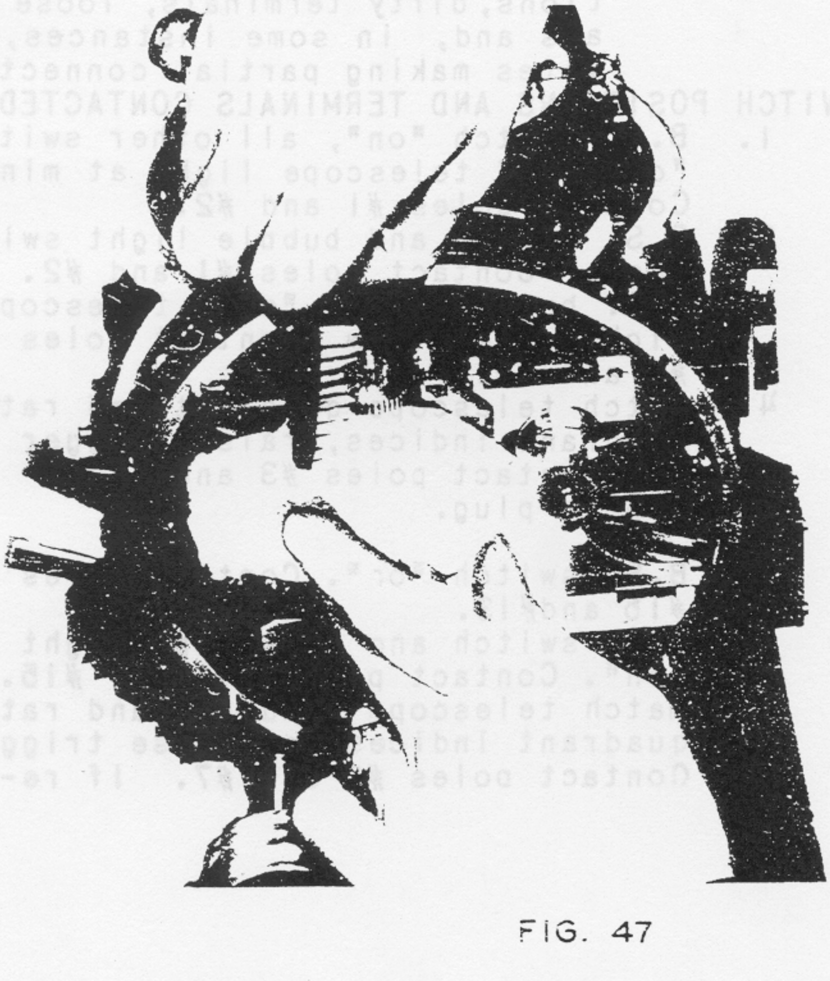


FIG. 47

sistance is obtained points are dirty.

4. B.S., telescope light and telescope motor "on". Contact poles #15 and #13. 4 ohms

d. Gears, Sight.

Fig. 46
Fig. 47

1. Check all gears for burrs, and remove the burrs with a knife-edge Arkansas Stone.
2. Clean all gear teeth with an orange stick or brush and benzine, or other suitable solvent. If brush and solvent is used, dirt and solvent should be caught on a cloth held next to the gear being cleaned so that other parts will not be affected.

SPECIFIC UNITS Fifty Hour Inspection (Cont'd)

1. Telescope Motor

1. Cleaning.

A. If governor pivots are binding, clean with kerosene or benzine.

B. Clean bearings using the following cleaning solutions.

1. Tectyl.
2. No Fome.
3. L. and R. Rinse.
   When using the above use in order given. If the above solutions are not available use
4. Benzine
5. Acid-free kerosine.
6. Alcohol.

CAUTION: Never spin a bearing that is dirty, as the balls and races will be damaged. A clean bearing will turn freely. After cleaning, dry the bearing and then inspect with a loupe. Be sure to oil the bearing after cleaning.

Fig. 48
Fig. 49

C. Remove dust and dirt from case with alcohol moistened cotton swab. Also clean all bright metal with either alcohol or carbon tet., and wipe off with clean white cloth.

D. Clean the commutator with carbon tet., and wipe with clean white dry cloth.

E. Clean the brushes and brush tubes with alcohol or carbon tet.

2. Oiling.

a. If the armature shaft bearings are removed and washed, oil with one drop of light bombsight oil.
DO NOT OVEROIL.

CHECKING BEARINGS FOR DIRT AND FLAT SPOTS

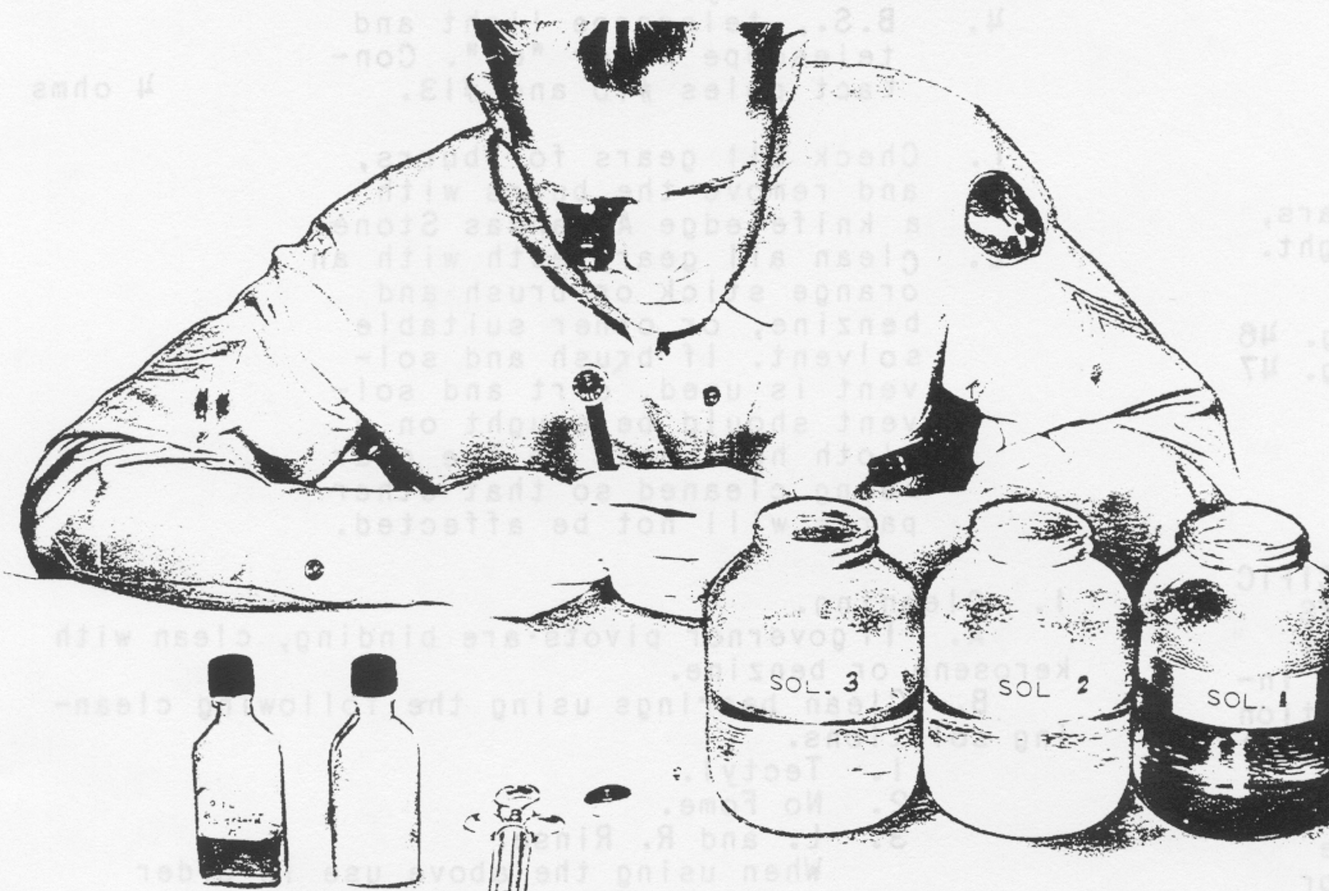


FIG. 49

CLEANING BEARINGS

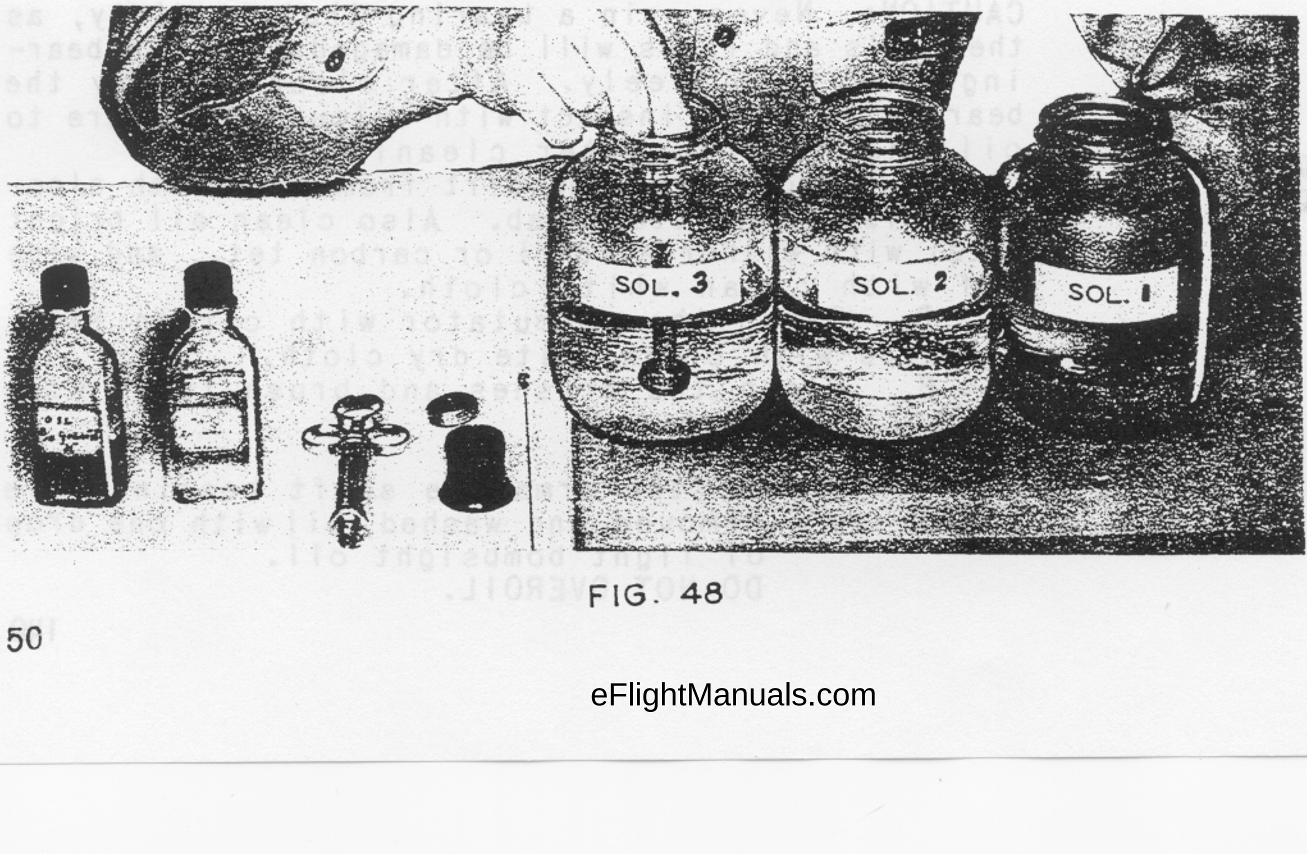


FIG. 48

3. Brushes.

Replacement of Brushes

Fig. 45 pg. 135

a. To remove brushes on the telescope motor loosen two screws that hold the lower field pole plate (from the outside of the housing); move the field assembly away from the commutator. Remove both brush brackets together. Never loosen or remove fiber terminal block as this will spoil radius of brushes.

The telescope motor brushes should be replaced when they no longer form an angle of 180° with the commutator.

The telescope motor brush spring should extend to a length of 1-3/32" when supporting a 4-1/2 oz. weight. Measure to end loop centers. This spring comes extra long in spare parts and it will be necessary, when installing a new one, to clip off one coil at a time and reform the end loops as necessary.

Commutator

If the commutator is rough, remove from housing and polish with #400 aluminum oxide paper and crocus cloth. It is best to put the commutator in a lathe on its own bearings and to rotate the commutator as the #400 aluminum oxide paper and crocus cloth are used. This will preventlow spots.

If the commutator is very rough, pitted and worn it should be turned down in a lathe on its own bearings by an experienced machinest. (This is a depot or factory job.)

No warm-up is required, under ordinary operation conditions, for the telescope motor.

Check Governor

Disconnect governor lever from governor, set armature shaft vertical and close governor by hand; it should fall under its own weight. It should still fall under its own weight with shaft held about 15° out of the vertical. If pivots bind, disc speed cannot be adjusted and it will be necessary to clean the pivots with kerosene, or benzine, catching dirt and solvent on cloth. Re-oil with a drop or two of light oil. Wipe off all excess oil.

Care and Adjustment of Governor Points

Set the stationary point so that 1/2 of the governor movement is required in taking up slack, and the remaining 1/2 in opening the points. This check is made on governor slide and adjusted by positioning the fixed governor point.

CHECKING DISC SPEED

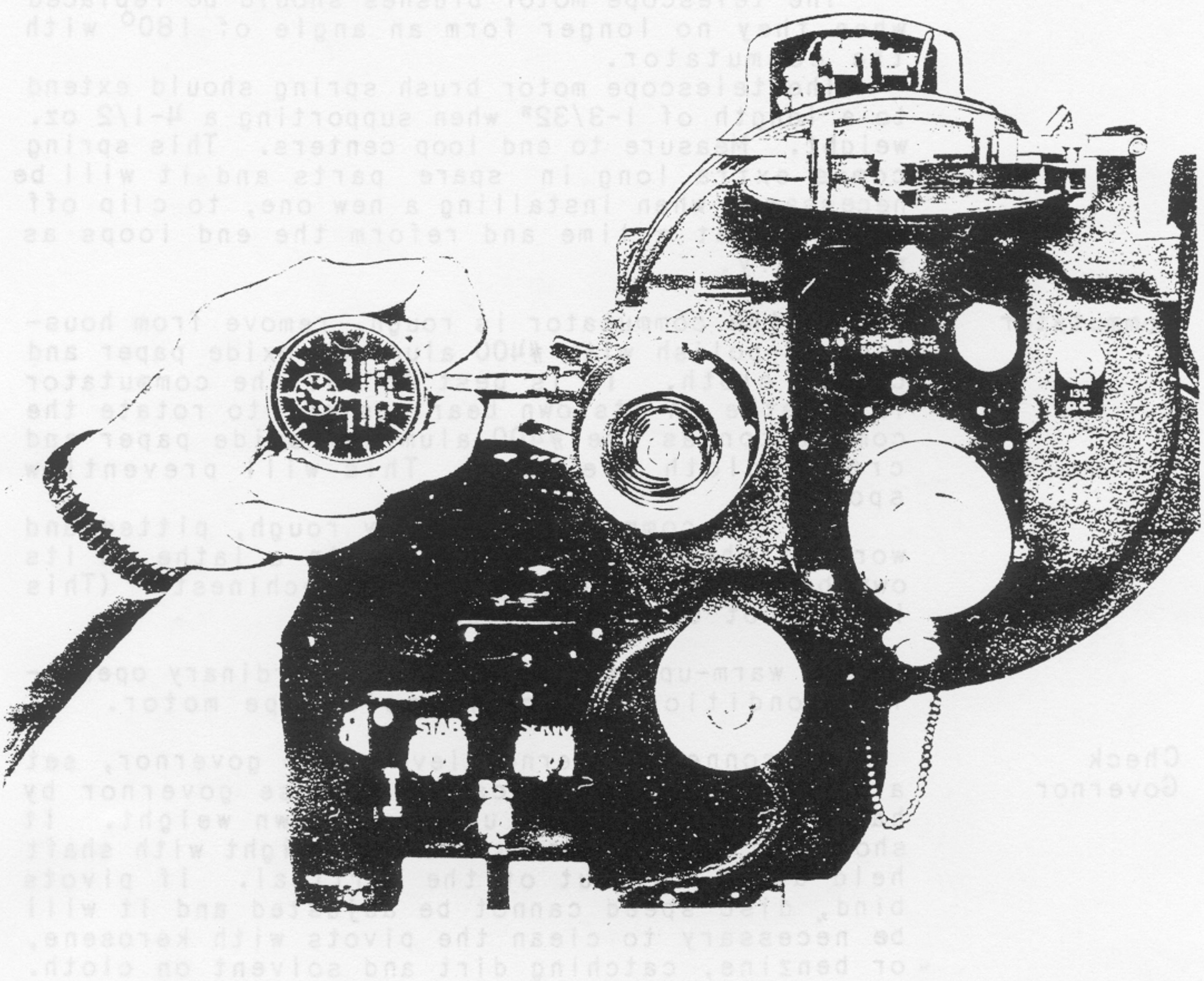


FIG. 50

If a teat builds up on the governor points, remove with orange stick and check positions of arc across the points. At low speed the arc should be across the top center of the points; at higher speeds it moves down closer to the center of the points. The points should make contact at the top. This is obtained by stoning the lever point to about a four-degree angle.

The use of a cigarette paper to clean the points at each 15-hour check will prolong the life of the points.

CAUTION: Any adjustment of the governor points will change the calibration of the altitude knob. Always check altitude knob and make necessary adjustments.

2.
Altitude
Knob
C.L.I.
B 43-5

Fig. 32

pg. 66

NOTE: Do not remove outer spring case in disassembly or maintenance. It is not necessary to remove outer spring and case to calibrate altitude knob. Altitude knob will be calibrated as per C.L.I. 43-5. Each time the altitude knob is calibrated a new piece of paper, cut to fit, will be placed on the outer shell of the altitude knob.

1. Turn on telescope motor and take maximum and minimum tachometer readings.

a. The following readings are correct:
M-3:
Minimum speed 117 plus or minus 1/2.
Maximum " 417 " " " "
M-6:
Shift on low:
Low 101 / 101 1/2
Med. 145
Fast 246 plus or minus 1/2.
Shift on high:
Low 246 plus or minus 1/2-
Med. 348 - 350
Fast 593

2. If the altitude knob is out of adjustment and if you do not receive the above reading, proceed a as follows:

a. Adjust high altitude, inner spring first. Turn counter-clockwise to decrease disc speed and clockwise to increase disc speed. Before attempting to adjust case, make certain that set screws are loosened.

b. Adjust low altitude, outer spring, next. Turn counter-clockwise to decrease disc speed and clockwise to increase disc speed. Always loosen set screws before attempting to adjust spring.

M-3 3. The high altitude spring is approximately half wound before the low altitude spring comes into operation. Fig. 50

Minimum speed-117 plus or minus 1/2 r.p.m.
Medium speed-202 " " " " " .
Maximum speed-417 " " " " " .

After minimum and maximum disc speed are adjusted rotate the altitude knob until the clutch holder of the low altitude spring barely contacts the clutch holder of the high altitude spring. If the correct medium disc speed is not obtained adjust the stationary telescope motor point. Recheck minimum and maximum and then recheck medium disc speeds.

M-6 Adjust the altitude springs to give the following speeds.

Shift on low:

Low	101 plus or minus 1/2 r.p.m.
Medium	145
Fast	246 plus or minus 1/2 r.p.m.

Shift on high:

Low	246
Medium	348-350
Fast	593

With the gear shift on low, the low altitude spring should cut in at 145, and, with the gear shift in high position, the low altitude spring should cut in at 348 to 350.

This can be accomplished by removing the outer case, loosening the set screws and by rotating the cases to obtain the correct tension on the springs.

If the altitude knob creeps, tighten the brakes. The brakes are the two flat leaf springs, with a screw through the center, which apply a tension against the fiber brake ring. Only the outer calibrated knob needs to be removed for this adjustment.

Oiling

Oil the bearings with one drop of light oil if bearings are removed and cleaned.

PRECAUTION: If, for some reason, the spring cases must be removed, be very careful not to bend the springs. Once the springs are bent out of shape the tension applied will be different and it may be difficult or impossible to correctly calibrate the altitude knob.

3. Disc

The disc must be kept free of dirt and dust. Clean with benzine or alcohol. Rub dry with clean white cloth. Apply a film of light bombsight oil. Remove, with a clean white cloth, all excess oil. Oil the smooth bearing on the disc shaft and the tachometer shaft bearing with one drop of light oil if removed and cleaned.

DO NOT OVEROIL. NEVER USE AN ABRASIVE ON THE DISC.

The spring tension on the disc is tested by a 2 lb. weight.

4. Rate and Displacement Knobs

Check for freedom of movement. If knobs do not move freely, disassemble and clean with benzine, alcohol or carbon tetrachloride. Oil all working parts with light bombsight oil. Remove all excess oil with a clean white cloth.

B. Rate End Computer Half.

Keep the rate end free of dust and dirt. Keep all gears clean.

The rate end requires very little oil. A thin film of oil is all that is needed on the smooth bearings, racks and spindle screw.

I. Roller

Fig. 33
pg. 68

The roller is a very important part of the computer system and must be kept in perfect working condition. Keep roller free from dust and dirt. Clean with benzine and alcohol, coat with film of light bombsight oil. Remove all excess oil with clean white cloth. When cleaning the roller, be very careful that no dirt or other particles get into the bearing. This bearing must be clean, for a very tiny particle will cause binding and erratic roller speed.

N.O.P.
#650
pg. 26

The roller should never be positioned at the center of the disc except for test purposes, because a flat spot will be worn on the roller and a depression worn on the center of the disc. A flat spot on roller is easily detected by the use of a loupe.

2. Automatic Release Mechanism (Sight)

Set the points to close when the telescope and rate indicators are perfectly matched. The points are mounted on the rate quadrant. Adjustments are made on the movable point.

INSTALLATION OF TELESCOPE CABLE M-4 AND UP

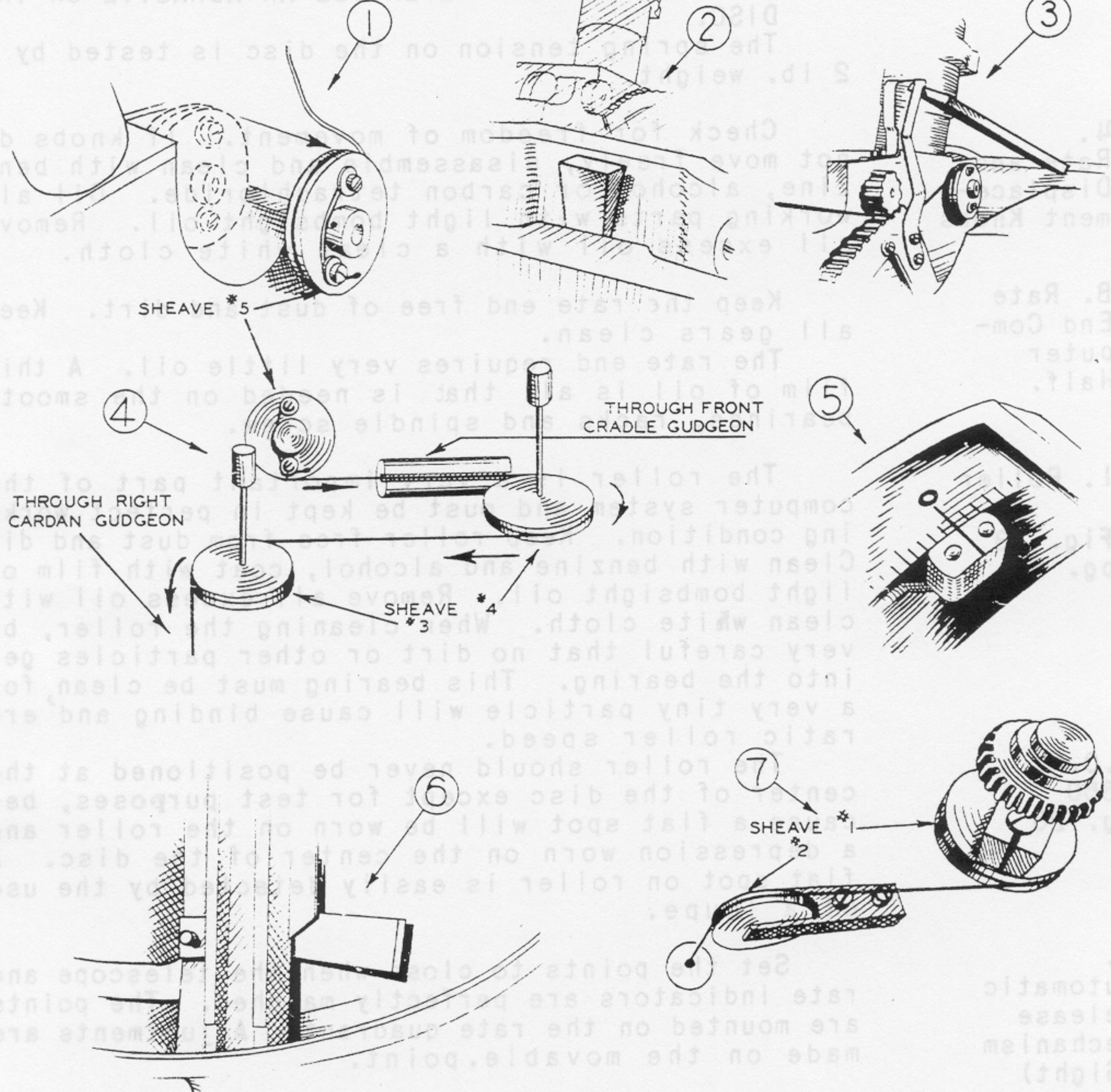


FIG. 51

Automatic Release Mechanism (Cont'd)

Keep points clean.

If a resistance is obtained on this circuit, with the points closed, the points are dirty.

Be sure that bombsight plug is disconnected.

Not more than 1/32" should be removed or dressed from points, or 1/64" from each point.

3. Forward View Mechanism

a\. M-3

Check for binding, dirt, and proper operation of prism.

b\. M-6

Check for binding, dirt, and proper operation of rotating mirror.

If the assembly binds, clean and oil with minute amount of light bombsight oil.

4. Sheaves.

Check sheaves for dirt, nicks and dents. If the sheaves are dirty clean with sharpened orange stick. If sheaves are nicked remove nicks with knife edge Arkansas Stone. If sheave is bent, it should be replaced.

NOTE: CARELESSNESS ON THE PART OF THE MAINTENANCE PERSONNEL IS RESPONSIBLE FOR DAMAGED SHEAVES. SHEAVES MUST ROTATE FREELY ON THE PINS.

5. Installation of Telescope Cable M-3

See Section V, page 75.

M-4's and Up

a. Remove No. 5 sheave, and No. 5 integral shaft pinion.

b. Thread the cable through the eyelet in #5 sheave, and form a half loop in the soldered end of the cable slightly larger than the anchor screw. Remove the anchor screw and washer and place the looped end of the cable under the washer. Replace the washer and screw, tightening the screw slightly. Pull the cable taut under the washer next to the eyelet and tighten the screw. Tighten the anchor screw.

c. Wedge the cardan so that #4 sheave is above housing.

d. Rotate the mirror to min. sighting angle, and place a wedge between the gear sector and the cardan to hold it at min. A toothpick may be placed between the teeth of the integral shaft pinion and the gear sector or a piece of cord or cloth may be used. The gear sector pointer should now be ahead of index as far as possible.

ZEROING THE ROLLER

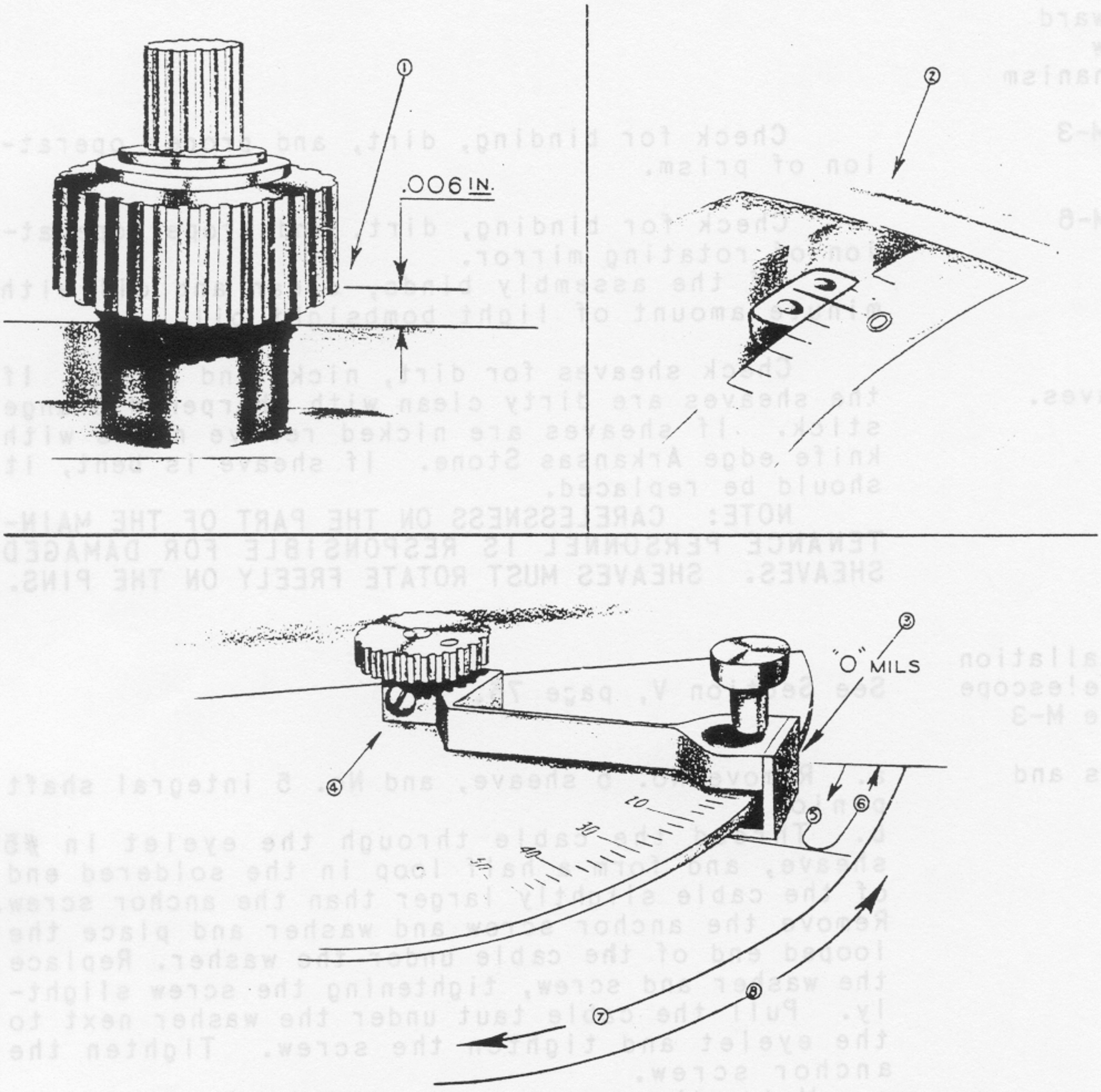


FIG. 52

e. Thread the cable through the front telescope cradle gudgeon.
f. Holding the #5 sheave in place (taper pin hole vertical, large end of hole up), remesh the integral shaft pinion with the gear sector. (Taper pin hole in the integral shaft should be in the same position as the sheave.) INSERT THE TAPER PIN.
g. Place the tel. quad. at zero sighting angle, and place a fiber wedge between the quad. and rate end housing to hold the quad. at exactly zero; in case of the modified M-6 make certain the 20° forward view is taken out.
h. Thread the cable past #4, #3, #2 around #1 and through the eyelet in #1 sheave, holding a slight tension on the tel. cable to hold it in the sheaves.
i. Pulling on the tel. cable slightly, remove the wedge holding gear sector.
j. Slip the cable sufficiently to align the gear sector pointer with its index; extreme binding may result due to the fact that the cable is all the way around the #1 sheave; therefore, it may be necessary to pull on the cable with the fingers between the #1 and #2 sheaves to prevent damaging the cable.
k. Apply a slight pressure on the gear sector pointer toward max. sighting angle to shape cable to sheaves, and take up any slack. Check adjustment. Correct if necessary and thread excess cable around eccentric. Remove the wedge from the tel. quad., and the wedges from the cardan.

6. Zeroing the Roller

1. The roller, when properly zeroed, should rest at the exact center of the disc with the rate quadrant at zero tangent value and with the trail arm at zero mil. There are three steps in zeroing of the roller.

A. ESTABLISH PROPER NUT GEAR CLEARANCE. The purpose of this step is to assure that the trail arm may be rotated to either of its extremes without first having either the nut gear bottom on the upper portion of the rate rack housing (when zero mils is approached) or the retaining pin striking the lower portion of the spindle lower bearing housing (when maximum mils is approached.)

1. PROCEDURE. Remove rate end and establish nut gear clearance (2 teeth---.006---10 mils.) In some sights the spindle gear or pinion does not bottom on the thrust washer when the nut gear bottoms on the rate rack frame; therefore the nut gear must be rotated until the thrust washer rests against the spindle gear and then rotate nut gear 2 teeth movement so that the spindle screw is translated upward.

B. ZERO THE ROLLER WITH THE RATE MECHANISM.

1. Clamp T.A. at zero.
2. Replace rate end and remove displacement knob plate.
3. Start telescope motor and set in maximum disc speed.
4. Move roller with rate mechanism until the roller stops rotating. At this point the roller is roughly zeroed, so it is necessary to proceed to the third step to find exact zero position.

NOTE: if at this point the rate indicator is off zero, it will be necessary to remove the three screws which hold the rate rack pinion gear in mesh with the rate rack and remesh it when the rate indicator has been restored to zero. Do not disturb the position of the roller or the T.A. This procedure will be necessary only if the original factory meshing relationship has been disturbed.

C. ZERO THE ROLLER BY DIVIDING BACKLASH.

At the center of the disc there is a "dead" area of 1 1/2 to 2 mils in diameter, i.e. when the roller reaches either the upper or lower extremity of this area it will stop rotating. Therefore, the rate mechanism cannot alone be used to find exact center of the disc.

1. Loosen T.A. from shaft, and unclamp from trail plate; slip T.A. to approximately 20 mils. (Be careful not to disturb nut gear). Clamp T.A. and trail plate, clamp T.A. to shaft.
2. Set maximum disc speed and turn telescope motor "on".
3. Move T.A. to maximum trail setting and then slowly back toward zero. When roller stops turning mark position. Repeat in opposite direction.
4. Position T.A. between two marks and clamp to trail plate.
5. Unclamp T.A. from shaft and slip it to zero. Reclamp. Recheck.

7. Zero Ground Speed Drum

So long as the rate rack pinion gear is not remeshed during the process of zeroing the roller, if the ground speed drum were at zero with the rate quadrant at zero, it will not be necessary to re-zero the ground speed drum after zeroing the roller.

A. Set rate quadrant at zero, and if ground speed drum indicator does not point at zero, loosen screw and reposition it to zero.

1. If gears are unmeshed at drums, spring will unwind. This spring is merely for the purpose of of taking up slack in the gear train. It is wound back about 1 1/2 turns at zero rate and ground speed.

8. Rough Field Check

1. Check for zero roller.
2. Divide the sight constant (M3 is 4580 and M6 is 5300 by the Actual Time of Fall to get disc speed).
3. Set disc speed into the sight using a tachometer.
4 Zero the trail arm.
5. Position the rate quadrant to set up any dropping angle.
6. Place the telescope quadrant behind the rate quadrant indices and turn on telescope motor and clutch in.
7. Start "stop" watch when the indices of the telescope and rate quadrants coincide.
8. Then check the time it takes the telescope quadrant to reach zero on the scale.
9. This time should equal the Actual Time of Fall set in to the sight to within one-tenth second.
10. Repeat this procedure with rate quadrant in two or three positions.
11. In event the actual time of fall does not check, look for the following difficulties:
    - (a) motor not driving constantly.
    - (b) roller slipping on disc.
    - (c) loose altitude knob brakes.

C. Gyro, Cardan and Telescope Assembly.

1. Telescope and Cradle Oiling.

1. Oiling.

A. Check cradle gudgeon bearings for freedom of action. If bearings are dirty, remove, clean, oil and replace.

B. Keep light film of oil on cross trail link pivot pin and also on gyro connecting rod pivot pin.

C. Cleaning.

a. Keep sector gear and integral shaft pinion free of dirt.

b. Polish mirror with optical paper, if obtainable.
c. Keep lens clean.
d. Keep all working parts free of dust and dirt.

2. Gyro Oiling.

I. Oiling.

A. On the M-Series sights that do not have the Norden Automatic Erection System, remove the upper bearing cap and check the gyro rotor bearing for oil. If the sight has the A.E.S., it is impossible to check accurately the rotor bearing for oil. Therefore check the running time of the sight and stabilizer. If they are nearly equal, then check a stabilizer gyro rotor bearing for oil. If the stabilizer rotor bearing needs oil, it is safe to assume that the sight rotor bearing needs oil. Do not overoil and never use more than I drop of heavy bombsight oil.

If one bearing is lubricated, always lubricate the other bearing. If one needs lubrication so will the other.

On sights where the bearing cap is removed, place one drop of heavy bombsight oil directly upon the balls. Do not touch the applicator to the balls.

When oiling the sight rotor bearing, if the A.E.S. has not been removed, place the oil in the tapered oil hole.

If gyro rotor bearings are oiled, always run gyro for ten minutes and then clean the commutator, brushes and brush tubes. The reason for this is that during operation all excess oil is thrown off in a fine spray. This spray settles on the commutator and brushes. Oil plus carbon dust makes a very fine grinding compound which will deeply groove the commutator and wear the brushes. Oil will also cause the brushes to soften and chip.

B. The carbon dust from brushes and metal from worn commutator will settle into the bearing and serious damage results.

C. Do not overoil rotor bearings and always clean commutator, brushes and brush tubes after oiling.

2. Check the gudgeon bearings for freedom of action. If the gyro does not move freely remove

the gudgeons and check the bearings for dirt. Oil gudgeon bearings only when cleaned. Use 1 drop of light bombsight oil.

PRECAUTIONS:

a. Do not attempt to oil the rotor bearing with a syringe unless expert enough to apply just enough pressure to the syringe to obtain one and only one drop of oil.
b. Use correct amount and grade of oil.
c. Do not apply oil while unit is moving.
d. Do not touch applicator to anything, for dirt will be transferred to the oil, and thence to the bearing. A metal applicator will also scratch the balls.
e. Place oil directly on balls between the inner and outer race.
f. Run unit for ten (10) minutes.
g. Clean commutator, brushes and brush tubes.

Cleaning.

3. Cleaning.

a. Gyro must be stopped to clean.
b. Before removing brushes, scribe head of brush plug and measure the amount it extends from the brush tube. The factory recommended adjustment is 1/4" on the sight gyro. Scribing makes replacement of the brush and plug to the same position exact.
c. Use clean white cloth moistened with carbon tet. or benzine (not alcohol) over the end of a soft wood stick, for cleaning commutators. Keep using a new section of the cloth until cloth comes out clean after being in contact with commutator. Scrape between segments (away from bearing) with wedge pointed orange stick. Never use metal stick of any kind for holding cloth on commutator.
d. Use very small amount of alcohol or carbon tet. for cleaning brushes and brush tubes. Do not use benzine.
e. If the commutator is rough or grooved, the gyro should be disassembled. Use #400 aluminum oxide paper to remove roughness and grooves. Care must

be taken or the commutator may be tapered or hollowed. Always check to make sure the commutator is not out of "round". If it is tapered or hollow in spots, the commutator must be turned down on a lathe; otherwise the gyro would be out of balance and the low spots would cause arcing and pitting of the commutator.

CAUTION: Never use an abrasive on the commutator while itis installed in the gyro case. Some of the abrasive will be deposited on the bearings and serious damage to the bearings will result. When an abrasive is used on a commutator, the commutator should be rotating on its own bearings in a lathe.

After an abrasive has been used on the commutator, always remove the burrs between the segments with #400 aluminum oxide paper, or a pointed stick, and clean with a white cloth moistened with carbon tet.

f. If the commutator is pitted it should be turned down in a lathe on its own bearings by an experienced machinist. (This is a depot or factory job.) If the commutator is worn, in the stabilizer, so that correct gyro speed cannot be obtained, or if proper precession is impossible, report the trouble and await disposition.

a.
Speed of Sight Gyro

1. The sight gyro turns approximately 7800 plus or minus 250 r.p.m. when operating on 13.5 volts or 26 volts.

b.
Replacement of Carbon Brushes

1. Carbon brushes will be replaced when 1/4" is worn from their length (as compared to a new one).
2. Installation of new carbon brushes.
   a. Check brush for fit in tube. Place spring and plug on pigtail; fold back 1/2"

of end of pigtail and refold that in half, leaving lead to brush coming between the folds, then clamp terminal over the four thicknesses. Do not cut the ends of the pigtails. They are cut to exact length at the factory.

b. Use no solder on connections, as solder destroys the balance of the gyro. Brush should make a minimum of 85% contact with the commutator. This is obtained by running in brush for a few minutes, then scraping the high spots (bright spots) with a sharp straight edged tool. Run in again and recheck. Continue until properly seated. **CAUTION:** Scrape very lightly.

c. The brush nuts should be turned down to exactly the same position as before removal. The factory recommended adjustment is, with the nut extended, 1/4" on the sight gyro. No change should be made in this setting to adjust the spring tension on the brushes. If the tension is not correct with this adjustment the cause is a defective spring or worn brush.

c.

Shaping Flexible Leads and Pigtails

1. Flexible leads.
   a. The flexible leads from the case to the cardan and from the cardan to the gyro, are heart shape in the M-3 and S shaped in the M-6.
   b. In shaping the flexible leads care must be used or leads will be damaged. Use an orange stick or glass rod to shape the leads. Do not use a piece of metal as the jagged edges will damage the insulation and shorten the usefulness of the lead.
   c. Always check to see that leads do not touch each other or anything as gyro is moved through its limits.
   d. Always check before turning on bombsight switch.
2. Pigtails.
   a. Pigtails are shaped so that they enter the brush plug at an angle of 180° and curved to the terminal so that they do not touch anything as the gyro is precessed.

PRECESSION (LEVELING) KNOBS

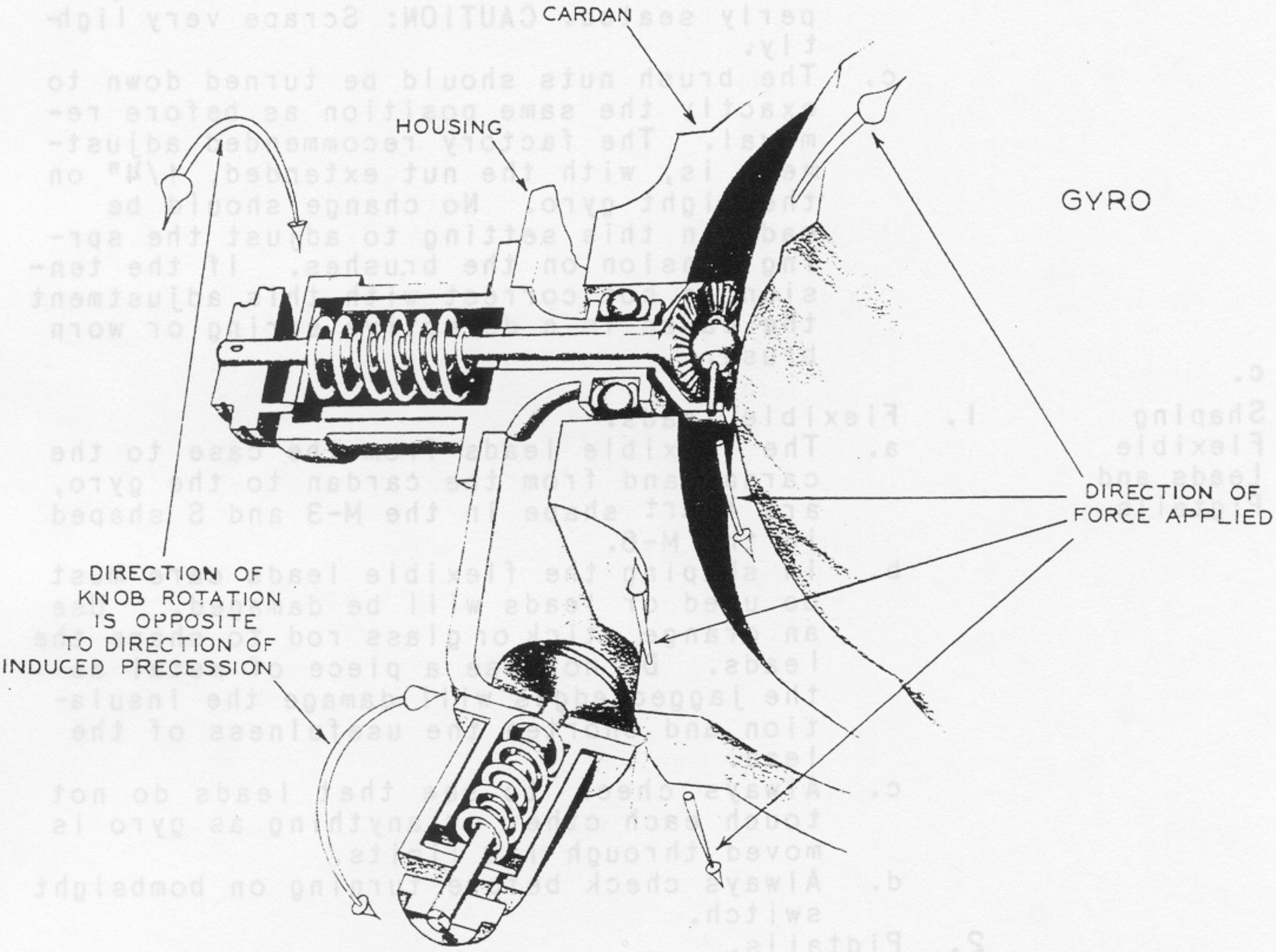
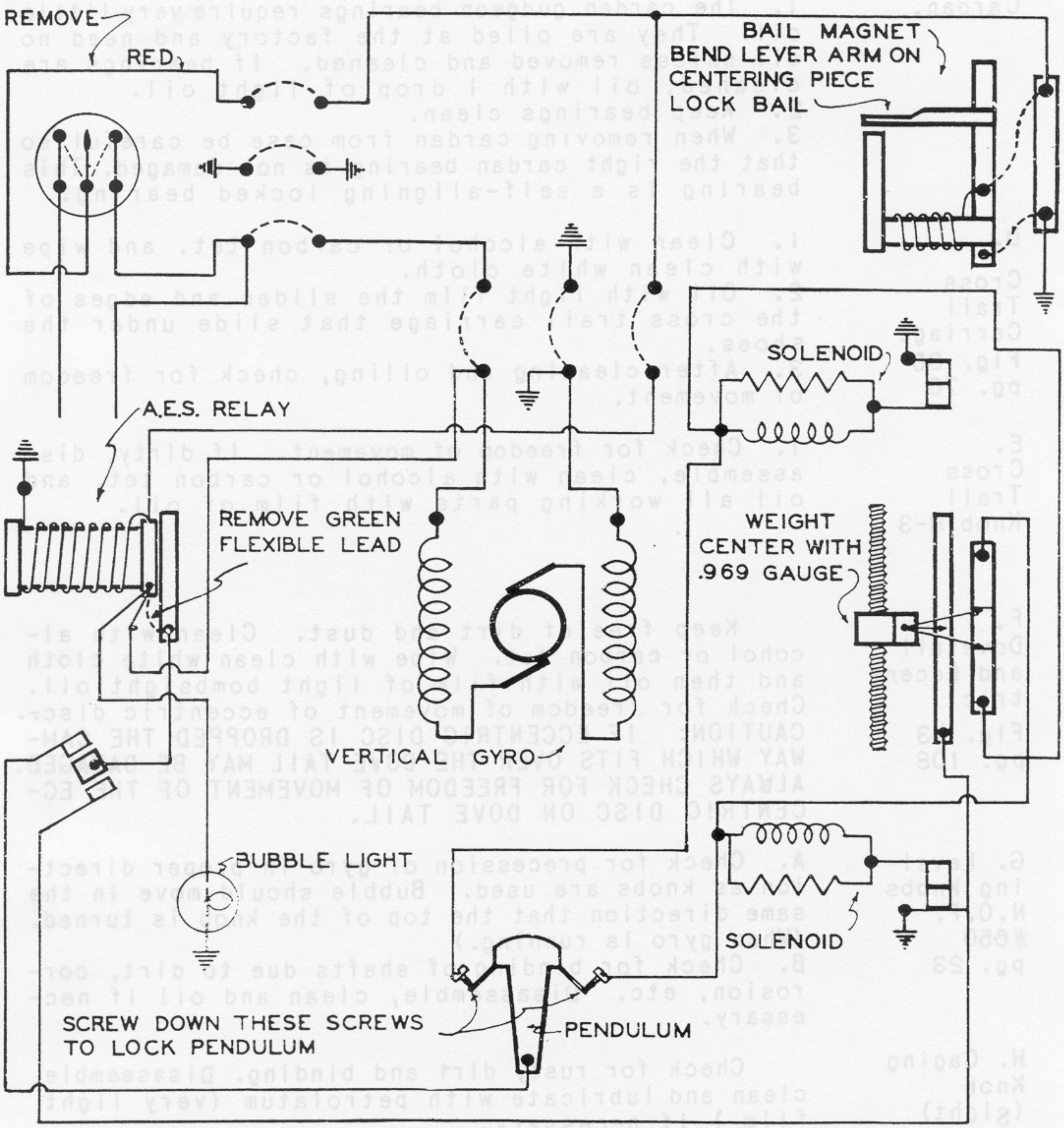

CARDAN
HOUSING
GYRO
DIRECTION OF FORCE APPLIED
DIRECTION OF KNOB ROTATION IS OPPOSITE TO DIRECTION OF INDUCED PRECESSION

FIG. 53

3. Cardan.	1. The cardan gudgeon bearings require very little oil. They are oiled at the factory and need no oil unless removed and cleaned. If bearings are cleaned, oil with 1 drop of light oil. 2. Keep bearings clean. 3. When removing cardan from case be careful so that the right cardan bearing is not damaged. This bearing is a self-aligning locked bearing.
D. Cross Trail Carriage Fig. 35 pg. 76	1. Clean with alcohol or carbon tet. and wipe with clean white cloth. 2. Oil with light film the slides and edges of the cross trail carriage that slide under the shoes. 3. After cleaning and oiling, check for freedom of movement.
E. Cross Trail Knob M-3	1. Check for freedom of movement. If dirty, disassemble, clean with alcohol or carbon tet. and oil all working parts with film of oil.
F. Dovetail and Eccentric Fig. 43 pg. 108	Keep free of dirt and dust. Clean with alcohol or carbon tet. Wipe with clean white cloth and then oil with film of light bombsight oil. Check for freedom of movement of eccentric disc. CAUTION: IF ECCENTRIC DISC IS DROPPED THE CAMWAY WHICH FITS OVER THE DOVE TAIL MAY BE DAMAGED. ALWAYS CHECK FOR FREEDOM OF MOVEMENT OF THE ECCENTRIC DISC ON DOVE TAIL.
G. Leveling Knobs N.O.P. #650 pg. 23	A. Check for precession of gyro in proper direction as knobs are used. Bubble should move in the same direction that the top of the knob is turned. (When gyro is running.) B. Check for binding of shafts due to dirt, corrosion, etc. Disassemble, clean and oil if necessary.
H. Caging Knob (Sight)	Check for rust, dirt and binding. Disassemble, clean and lubricate with petrolatum (very light film) if necessary.
I. Drift Pointer Clearance	The drift pointer on the sight should clear the drift scale on the Stab. by .012". Obtain this clearance by stoning off the underside of the pointer.


REMOVE
RED
BAIL MAGNET
BEND LEVER ARM ON CENTERING PIECE
LOCK BAIL
SOLENOID
A.E.S. RELAY
REMOVE GREEN FLEXIBLE LEAD
WEIGHT CENTER WITH .969 GAUGE
VERTICAL GYRO
BUBBLE LIGHT
SOLENOID
SCREW DOWN THESE SCREWS TO LOCK PENDULUM
PENDULUM

WIRING CHANGES IN ORDER TO RENDER A.E.S. INOPERATIVE
(IN ACCORDANCE WITH C.L.I. B-43-20)

FIG. 54

J. Course Knobs
Fig. 31
pg. 64

A. Adjust backlash between turn worm and Stab. sector gear with shims. Always place more shims between worm housing and sight, than will be necessary to obtain clearance; then remove .001" at a time to obtain minimum clearance without binding. The same number of shims should be placed between the course shaft bracket and the sight case as there are between the trun worm housing and the sight case. This will prevent warping and binding of the course shaft. Turn the knob through limits of Stab. sector each time sight is mounted. This keeps wear even on stabilized sector gear.
B. Loosen set screw in drift worm housing and rotate housing toward or away from drift gear to obtain .002" to .003" clearance. Check by rotating drift gear and note movement of P.D.I. brush; tighten set screw. Drag should be equal on each knob.

ADDITIONAL MAINTENANCE

A.
Changes In Order to Render A.E.S. Inoperative.
C.L.I. B-43-20

See also P. 177.

Because of the additional maintenance required, and the unfavorable conditions under which the bombsight equipment must very often operate, it is directed that "service personnel" make the A.E.S. inoperative until the bombsight is sent to a depot for overhauling. When the bombsight is sent to a depot for overhauling, the A.E.S. will be removed from the sight gyro, and the assembly will at this time be re-balanced. It is because the static balance of the gyro would be seriously effected, should the removal of the A.E.S. be affected by the "service personnel", that this order directs the removal of the sight to the depot for such a purpose.

The A.E.S. will be secured or locked in an inoperative position as follows:

1. Remove the red lead which connects the auto-manual switch to the front contact of the terminal block in the bombsight housing end cap.

2. Remove the small green lead which connects the movable contact bracket to the A.E.S. relay magnet assembly.

3. Secure the inverted pendulum in the vertical by screwing in the pendulum adjustable contacts an equal amount until all motion of the pendulum is completely stopped.

M-6 SIGHT WITHOUT A.E.S.

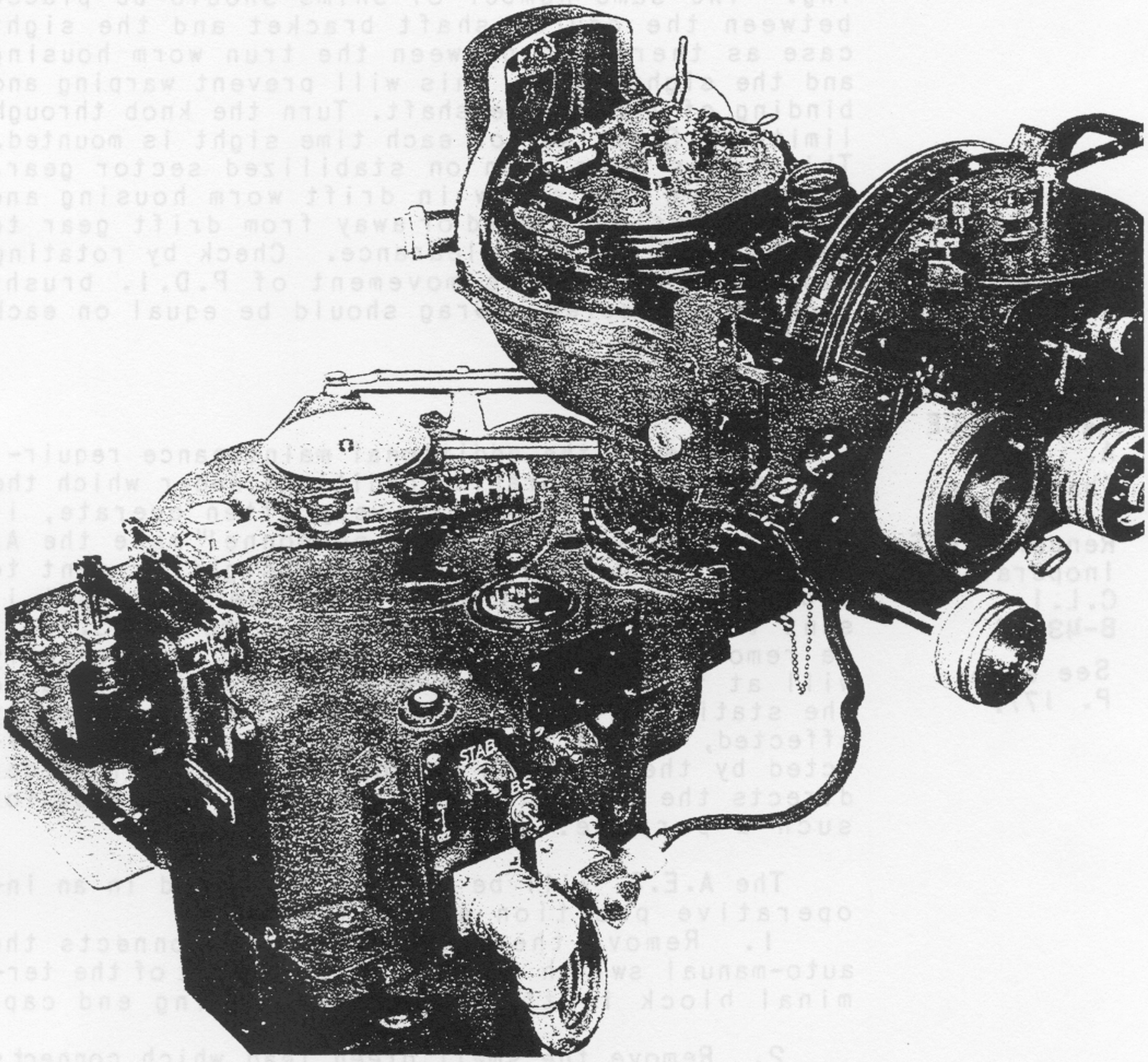


FIG. 55

A.
Changes In
Order To
Render
A.E.S.
Inoperative C.L.I.
B-43-20
(Cont'd)

4. Remove the centering piece from the A.E.S. bail magnet lever and bend the lower arm of the centering piece an amount sufficient to lock the centering peice in the "V" slot of the bail lock centering plate.

5. Replace the centering piece.

6. Center the weight by using the .969 gauge. (31/32").

7. Enter in Log Book.

Each time the unit is inspected, except the pre-flight inspection, check the position of the weight with the .969 guage because if in the maintenance of the unit or in any undue vibration of the unit while in use, the lead screw gear has been moved ever so slightly, the gyro will be out of balance.

Be sure to check and see whether brake is operating on the Solenoid shaft.

When locking the bail, check bail and see that the roller is centered and not riding on cork surfaces.

If the A.E.S. has not been removed keep gears operating from the rotor shaft free from dust and dirt to prevent binding. Remove the dust with alcohol moistened cotton swab. Clean gears with a sharpened orange stick.

CAUTION: DO NOT clean the gears while the gyro is running. Remove the screw in the top of the A.E.S. roller and oil with one drop of light bombsight oil every fifty (50) hours. Oil the bearing on top of the bronze gear with one drop of light oil every fifty (50) hours.

B.
Check For
Roller
Slippage
N.O.P.
#649
pgs. 51&
53.

1. It is possible to detect roller slippage by positioning the roller so that one revolution of the disc will cause one revolution of the roller.
2. Steps to Follow:
(a) Set rate indicator to 1.0 on the tangent scale.
(b) Set T-arm to 7 mils.
(c) Remove rate cover plate, make a pencil mark on the roller and disc to note their relative positions.

BOMB SIGHT AND STABILIZER M 9

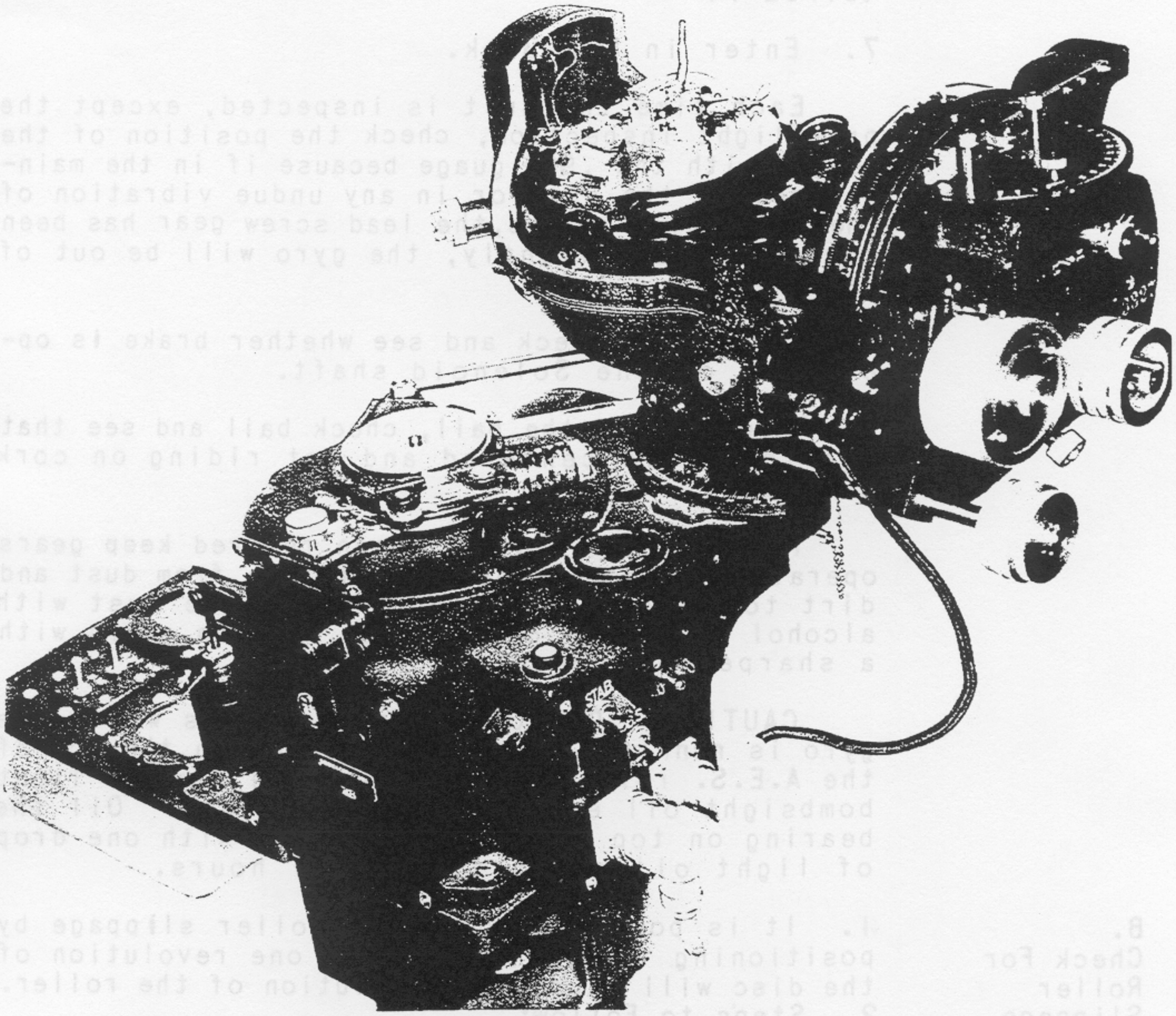


FIG. 56

(d) Turn the tachometer shaft a few revolutions to determine that a one to one ratio has been established. Fine adjustments can be made by moving the T-arm between 7&8 mils.

(e) Turn telescope motor "on".

(f) Set up maximum disc speed and run for approximately five (5) seconds.

(g) Check pencil marks to insure that no slippage has occured.

(h) Run disc for 15 seconds and check for slippage.

(i) Clutch in displacement knob clutch.

(j) Set telescope at maximum sighting angle.

(k) Repeat step (h) and check for slippage.

3. If there is any roller slippage it should not exceed 1/3 of the circumference of the roller.

4. If there is too much slippage check for:

(a) Weak disc spring.
(b) Oil on roller and disc.
(c) Too much friction.
(d) Telescope drive gearing and gear shafts.
(e) Telescope return spring tension.
(f) Flat spot on roller.

C. Installation of the Double Cable.

THIS CABLE SELDOM BREAKS THROUGH ORDINARY USAGE, AND REPLACEMENT SHOULD NOT BE NECESSARY UNTIL SIGHT IS SENT TO DEPOT FOR OVERHAUL.

a. Remove the telescope cable.

b. Remove #4 sheave and remove the telescope cradle from the cardan.

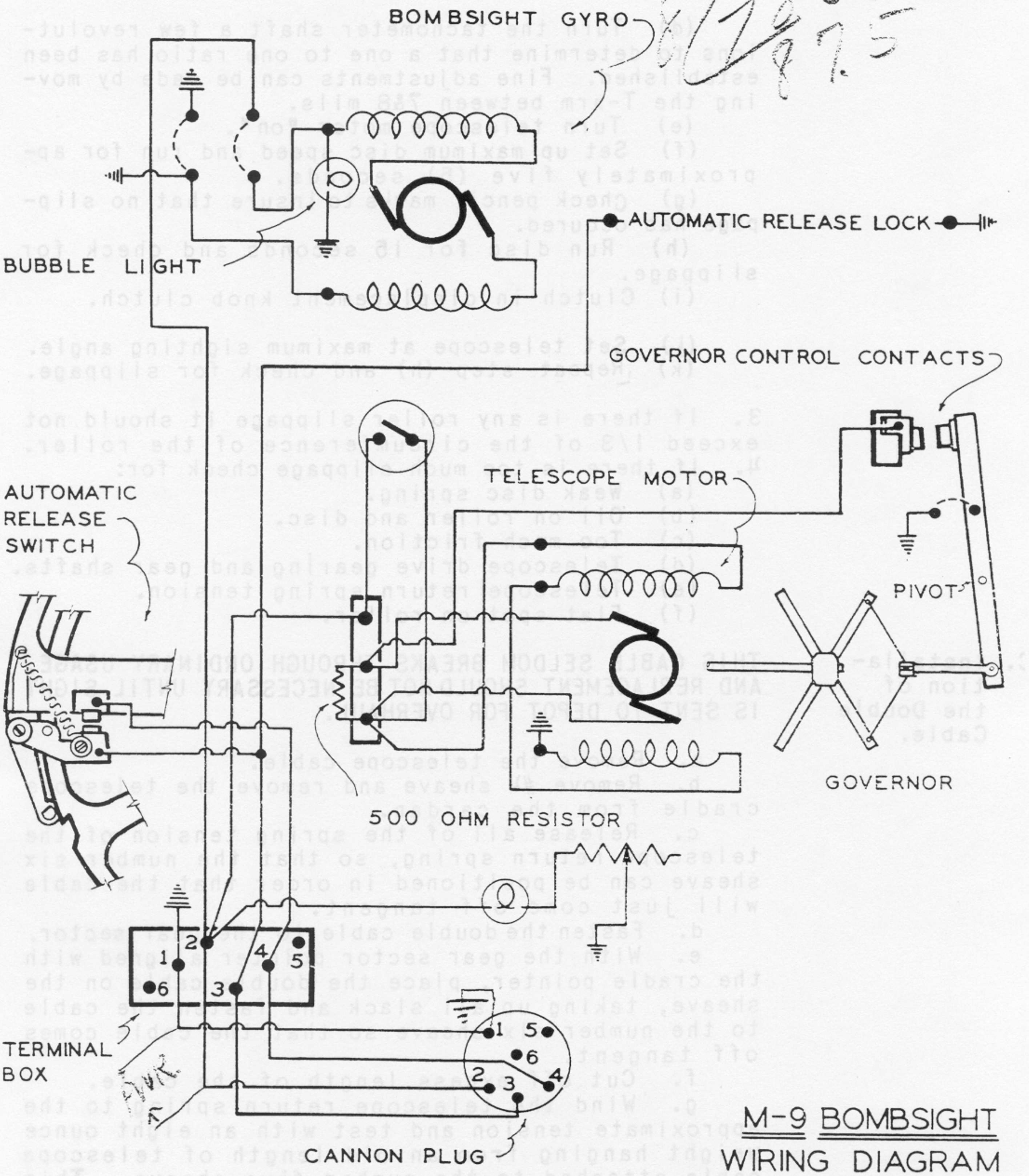
c. Release all of the spring tension of the telescope return spring, so that the number six sheave can be positioned in order that the cable will just come off tangent.

d. Fasten the double cable to the gear sector.

e. With the gear sector pointer aligned with the cradle pointer, place the double cable on the sheave, taking up all slack and fasten the cable to the number six sheave so that the cable comes off tangent.

f. Cut off excess length of the cable.

g. Wind the telescope return spring to the approximate tension and test with an eight ounce weight hanging from an old length of telescope cable attached to the number five sheave. This weight should align the gear sector pointer with the center of the telescope tube.



M-9 BOMBSIGHT
WIRING DIAGRAM

FIG. 57

h. If the above does not check, make the appropriate adjustment on the telescope return spring and check as before.

i. If the correct spring tension cannot be obtained, finer adjustment may be had by turning the telescope return spring housing 180°.

j. Precautions:

1. Care should be taken in order that the two lengths of the cable are not twisted.
2. The cable should not double wind.
3. Extreme care should be taken so that the sighting angle mirror does not become scratched or damaged.

C. Installation of The Double Cable(Cont'd)

D. Interchangeability of Sights.

In the interchanging of sights and stabilizers, the following points must be considered, checked, and necessary adjustments made.

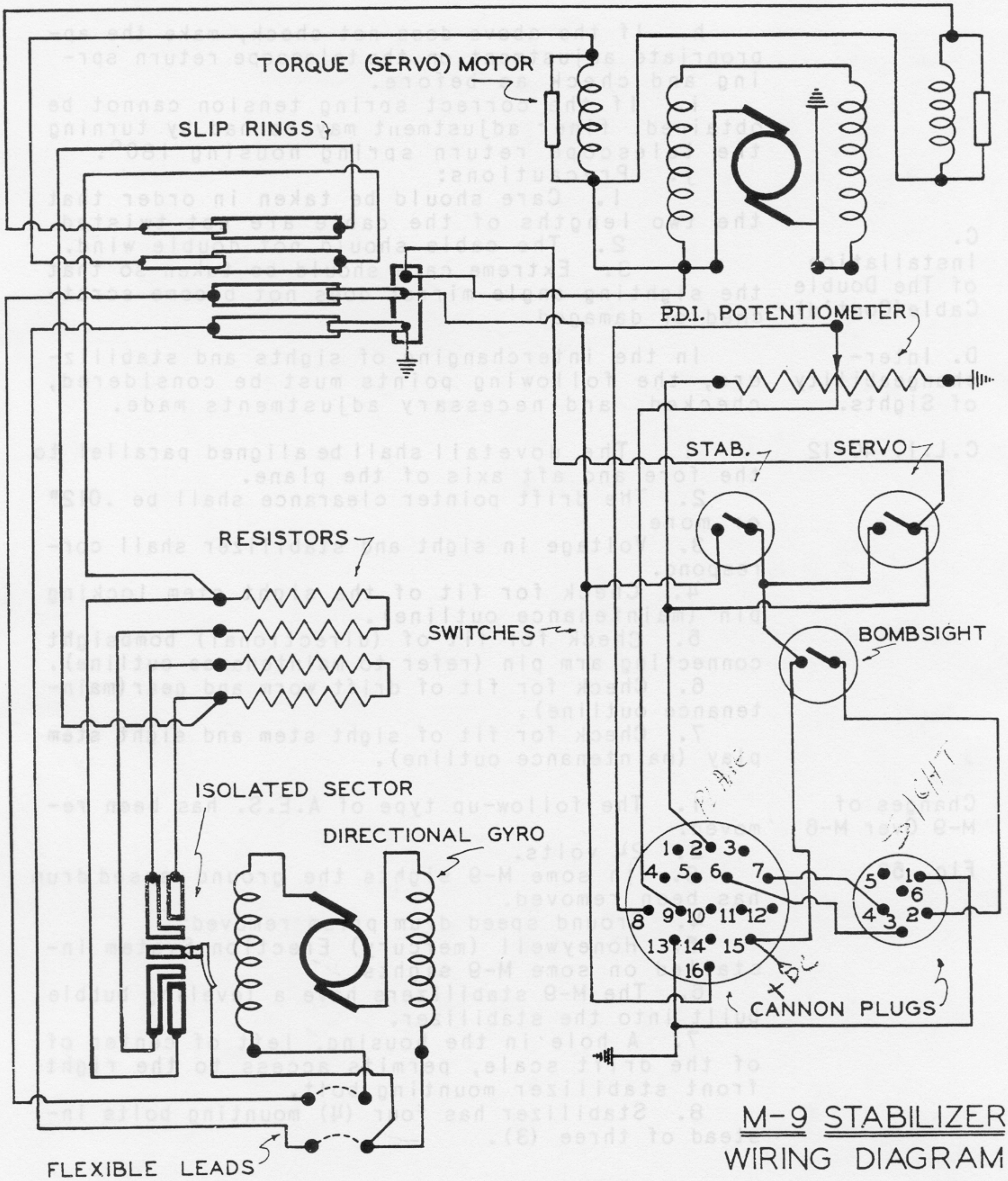
C.L.I. 40-12

1 The dovetail shall be aligned parallel to the fore and aft axis of the plane.
2. The drift pointer clearance shall be .012" or more.
3. Voltage in sight and stabilizer shall correspond.
4. Check for fit of the sight stem locking pin (maintenance outline).
5. Check for fit of (directional) bombsight connecting arm pin (refer to maintenance outline).
6. Check for fit of drift worm and gear(maintenance outline).
7. Check for fit of sight stem and sight stem play (maintenance outline).

Changes of M-9 Over M-6

Fig. 56

1. The follow-up type of A.E.S. has been removed.
2. 24 volts.
3. In some M-9 sights the ground speed drum has been removed.
4. Ground speed drum prism removed.
5. Honeywell (mercury) Erection System installed on some M-9 sights.
6. The M-9 stabilizers have a leveling bubble built into the stabilizer.
7. A hole in the housing, left of center of of the drift scale, permits access to the right front stabilizer mounting bolt.
8. Stabilizer has four (4) mounting bolts instead of three (3).



M-9 STABILIZER
WIRING DIAGRAM

FIG. 58

THIRTY DAY INSPECTION

C.L.I. B.42-31

A. Place the bombsight (and stabilizer of M-series) on bench in the shop at normal room temperature.
B. Run all gyros for a period of one hour with all cover plates on bombsight open.
C. Wipe off all exposed bright metal parts on the outside of the bombsight with clear carbon tet. to remove all foreign matter and moisture, particularly that resulting from finger prints.
D. Cover all exposed bright metal parts, on the outside of the bombsight only, with a light coating of bombsight oil, Grade "L", which is supplied with the bombsight. The oil should be applied with a soft camel hair brush and particular attention should be paid to any small exposed parts which are not plated, i.e., bombsight and autopilot clutches, the flat mechanism, cross trail mechanism, etc.
E. After running the gyros, the rotor shaft bearings will be inspected and a small drop of Grade "H" bombsight oil will be applied, after which the gyros will be operated from one (1) minute, and all cover plates and vents will be reinstalled and/or closed.
F. Store immediately in bombsight locker or storage case where the temperature remains between 40° and 125° Fahrenheit.
G. At intervals of thirty (30) days, the foregoing operation will be repeated. (While running the sight, all caging knobs will be released to allow free motion of the gyros and bearings).

U.R. No. 43-434-MQ

To Secure Counter Weight

Any number of measures may be taken to secure the counter weight in the center and as a suggestion it may be accomplished by winding a few turns of thread between the spindle drive gear, part No. 265549-4, and the Servo Motor pinion gear, part No. 265548-5. A drop of shellac on the thread will help preserve it and the slight increase in weight is practically negligible.

SECTION X

CALIBRATION

INTRODUCTION

If it were possible to single out any weapon of war as the most vital for victory, doubtless the airplane would be chosen. And the bombardment plane occupies the central position in any air force. The fighter planes exist largely to afford protection to our bombers when on a mission or to intercept enemy bombers when they are directed against us. Therefore the fighter is auxiliary to the bomber. The reconnaisance plane almost entirely devotes itself to obtaining information for use in future bombing missions or information as to the effectiveness of past bombing missions. It is true that airplanes other than bombers are used for direct attacks upon enemy troops or installations and for obtaining information which has no relation to a bombing mission. But these planes constitute only a small percentage of an air force.

The bomber exists to drop bombs. The bombsight is the instrument by which it is enabled to do so with any degree of accuracy. Not only does the bomber exist to engage in accurate bombing, but every man of her combat crew and her ground crew were trained toward the end that she may be enabled to drop bombs accurately. And, of course the accuracy and operation of the bombsight depend directly upon the effectiveness of the bombsight maintenance man. With so many lives, so much training, so much valuable equipment, and even victory itself at stake, the bombsight man should constantly appreciate the vital part he is called upon to play.

It may well be that faulty work on his part may result in nullifying the entire mission and even in loss of the bomber and her crew. Thus, if a bomber is attacking an enemy ship and misses with her first bomb release, on her second try she may be shot down. No American soldier wants to think he could be responsible for such a disaster. Conscientious application to his work will make it unnecessary for his mind ever to dwell upon such a thought, for it is possible on every mission to make certain the bombsight will function and will function accurately.

SET PEDESTAL REFERENCE INDEX

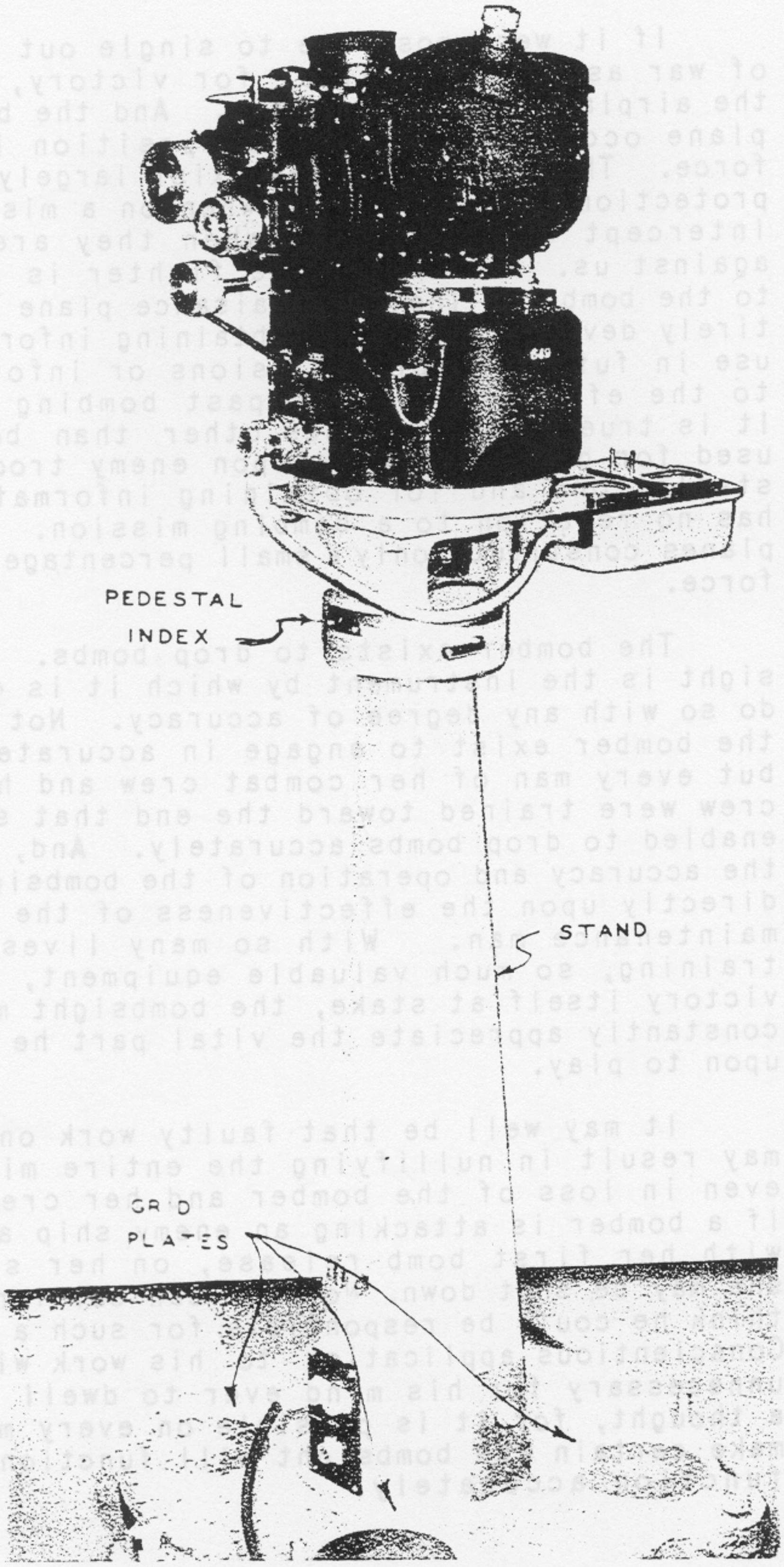


FIG. 59

SECTION X

CALIBRATION

CALIBRATION M6 SIGHT

N.O.P. #650 pg. 17-36

Before trying to calibrate any kind of precision instrument, it seems logical to presume that unless the tools, jigs, and measuring devices to be used are themselves in proper calibration, nothing will be gained by wasting time using them. Therefore, the calibration outline starts not with adjustment of instruments but with the proper methods for checking and adjusting the auxiliary equipment and its proper care.

The Instructor will perform each step in calibration and discuss it thoroughly before the students will proceed with calibration. Check the work of each student.

Fig. 59

A. SET PEDESTAL REFERENCE INDEX.

1. Bolt stabilizer to head of stand.
2. Install sight on stabilizer (do not drop sight into sight stem sleeve), and connect bombsight connecting rod to stabilized sector. Insert sight stem locking pin.
3. Set zero drift, align course centering marks on pointer, and clamp connecting rod to pointer.
4. Turn head of stand until point of intersection of cross hairs will track, as search knob is used, parallel to any grid line, and clamp head of stand.
5. Loosen pedestal reference index plate, and match index with closest index on head of stand. Tighten screws in plate.

Fig. 60

B. ESTABLISH GRID LINES ON TRUE HEADING. 2

1. Mark line on floor along any true heading. (A true heading in Bldg. 379 can be established by using a triangle which is properly marked in reference to the rectangles on the floor).
2. Turn base of stand (sight must be left at zero drift and pedestal index left matched) until point of intersection of cross hairs will track, as search knob is used, parallel to line on floor.

Fig. 61

C. CHECK ALIGNMENT OF VERTICAL HAIR. 3

1. Place a dot on sheet of paper and lay the paper on the floor about 8 feet from the base of the stand. Turn head of stand or sight to set vertical hair on dot. If vertical hair cuts across

GRID LINE ON TRUE HEADING

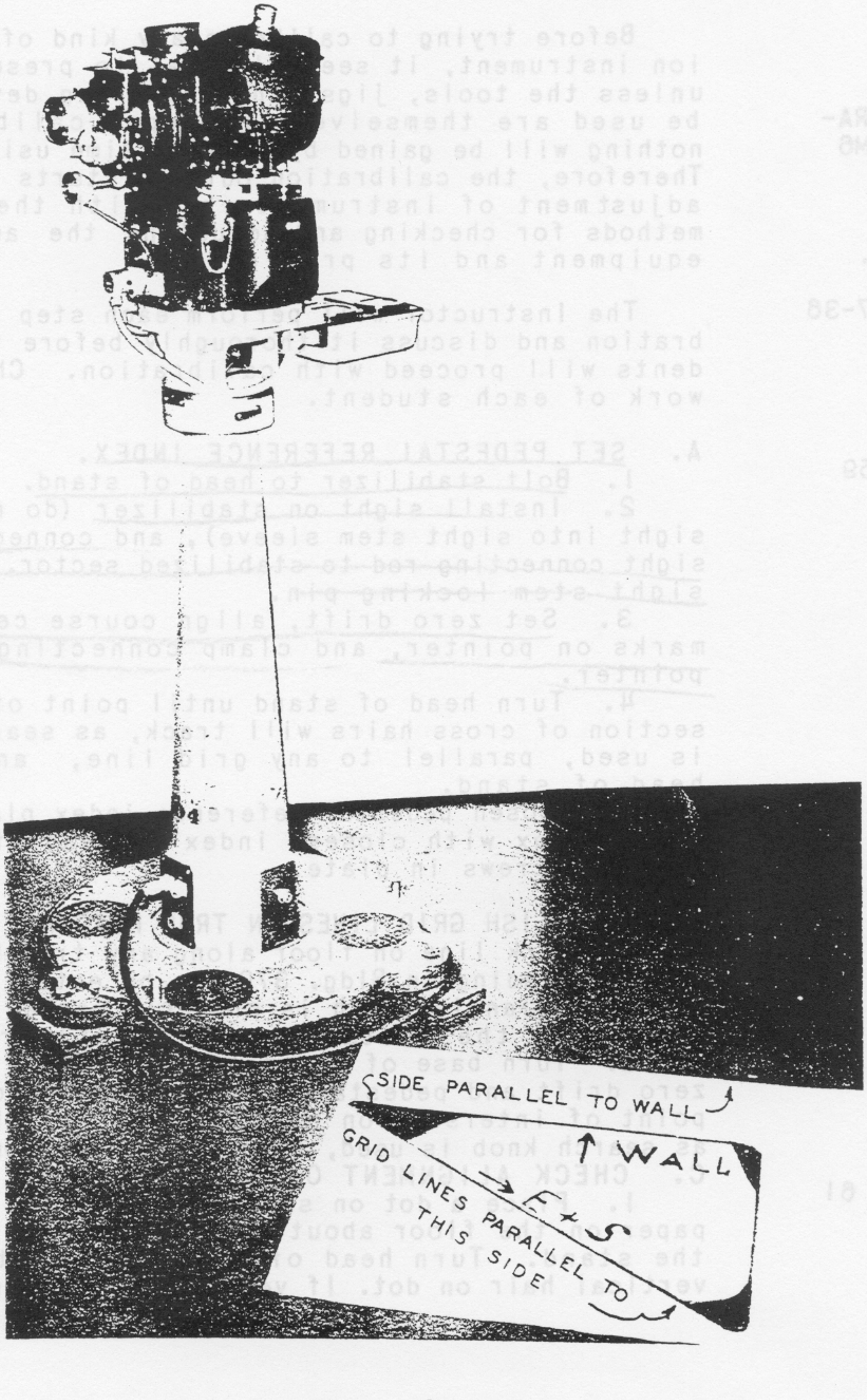


FIG. 60

ALIGNMENT OF VERTICAL HAIR

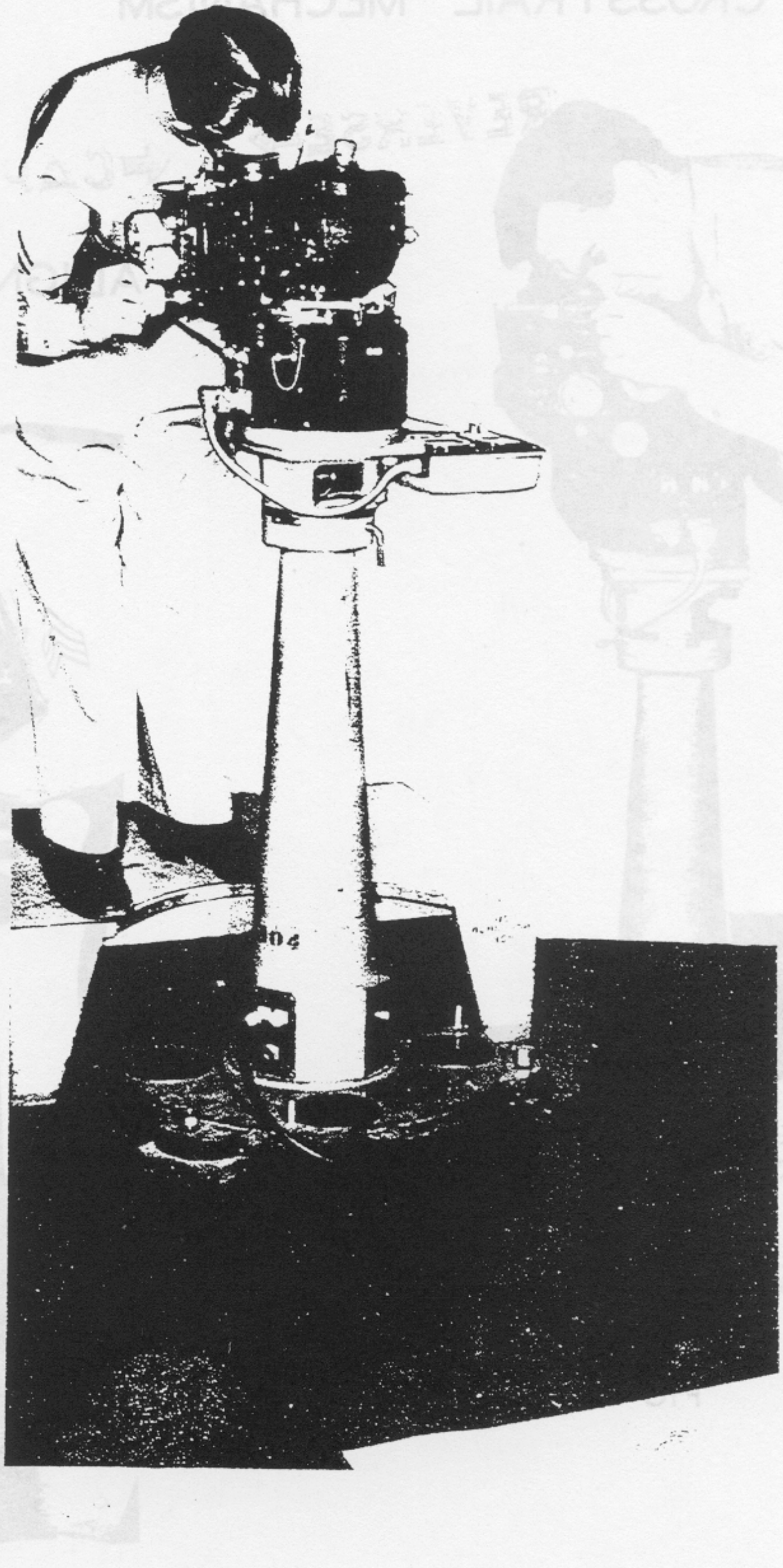


FIG. 61

SYNCHRONIZE TRAIL ARM WITH THE CROSSTRAIL MECHANISM

REVERSE ⇨ ⇦ CAPTIONS

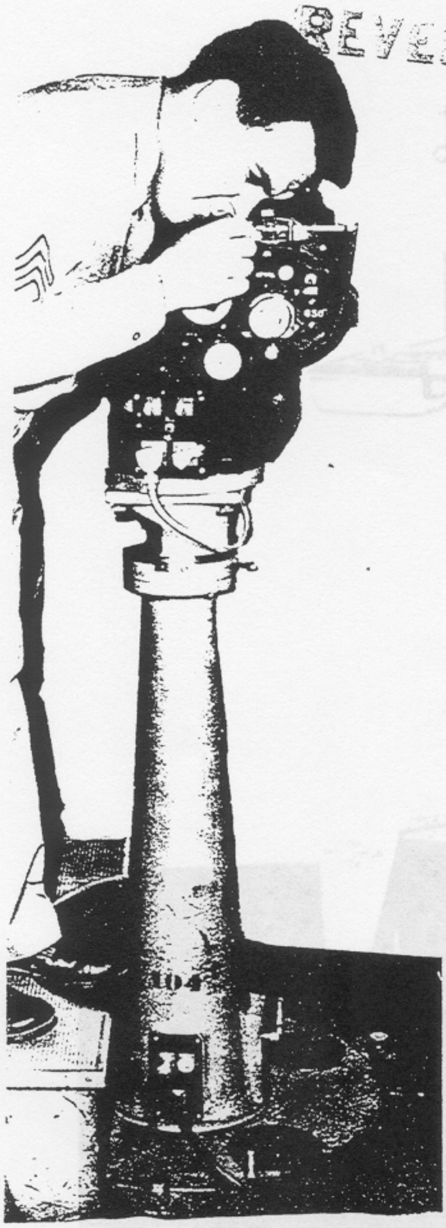


FIG. 62

ALIGN DOVE TAIL

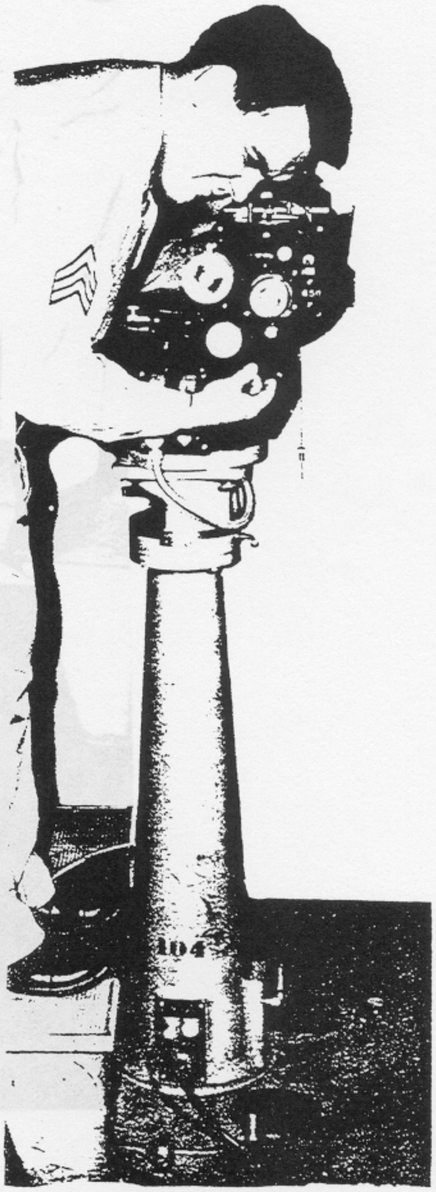


FIG. 63

dot, as search knob is used, reticle is out of adjustment. Do not try to adjust this condition, but report it to the depot.

Fig. 62

D. SYNCHRONIZE THE TRAIL ARM WITH THE CROSS TRAIL MECHANISM. 4

1. Lock trail arm to trail plate at exactly zero.
2. Remove spur gear from trail arm pivot.
3. Remove sight stem locking pin.
4. Set telescope indicator at zero, or very close to zero, and proceed as follows: Look through telescope at grid plate and rotate sight stem. If any movement of the vertical hair is noted, stop motion by moving trail rack slightly while sight stem is being rotated. Now remesh gear with with rack. If scribed lines do not match, recheck your work to make sure you are correct. If it still does not match, disregard scribed line (scribe new line). Tighten set screw and recheck. Fine adjustments can be made by using play around spur gear screw.
5. If one tooth change or correction of the spur gear in mesh with the rack proves to be too much correction, some adjustment can be made by placing shims between the bell crank brackets and sight case. In this case, spur gear and rack will be meshed matching scribed lines and correction made by using shims.

Fig. 63

E. ALIGN DOVETAIL PARALLEL TO FORE AND AFT AXIS OF STABILIZER. 5

1. Insert sight stem locking pin.
2. Set zero drift.
3. Rotate trail arm through its limits while watching through the optics at the grid plate.
4. If any movement of the vertical hair is noted, set trail arm at zero and note position of vertical hair on grid plate.
5. Set trail arm at 150 mils and again note position of vertical hair on grid plate.
6. Loosen screws in sight stem locking plate just enough so that it may be rotated, but not enough so that it will turn when the trail arm is rotated.
7. Leave trail arm set at 150 mils and rotate locking plate to bring the vertical hair back the

LEVEL HEAD OF STAND

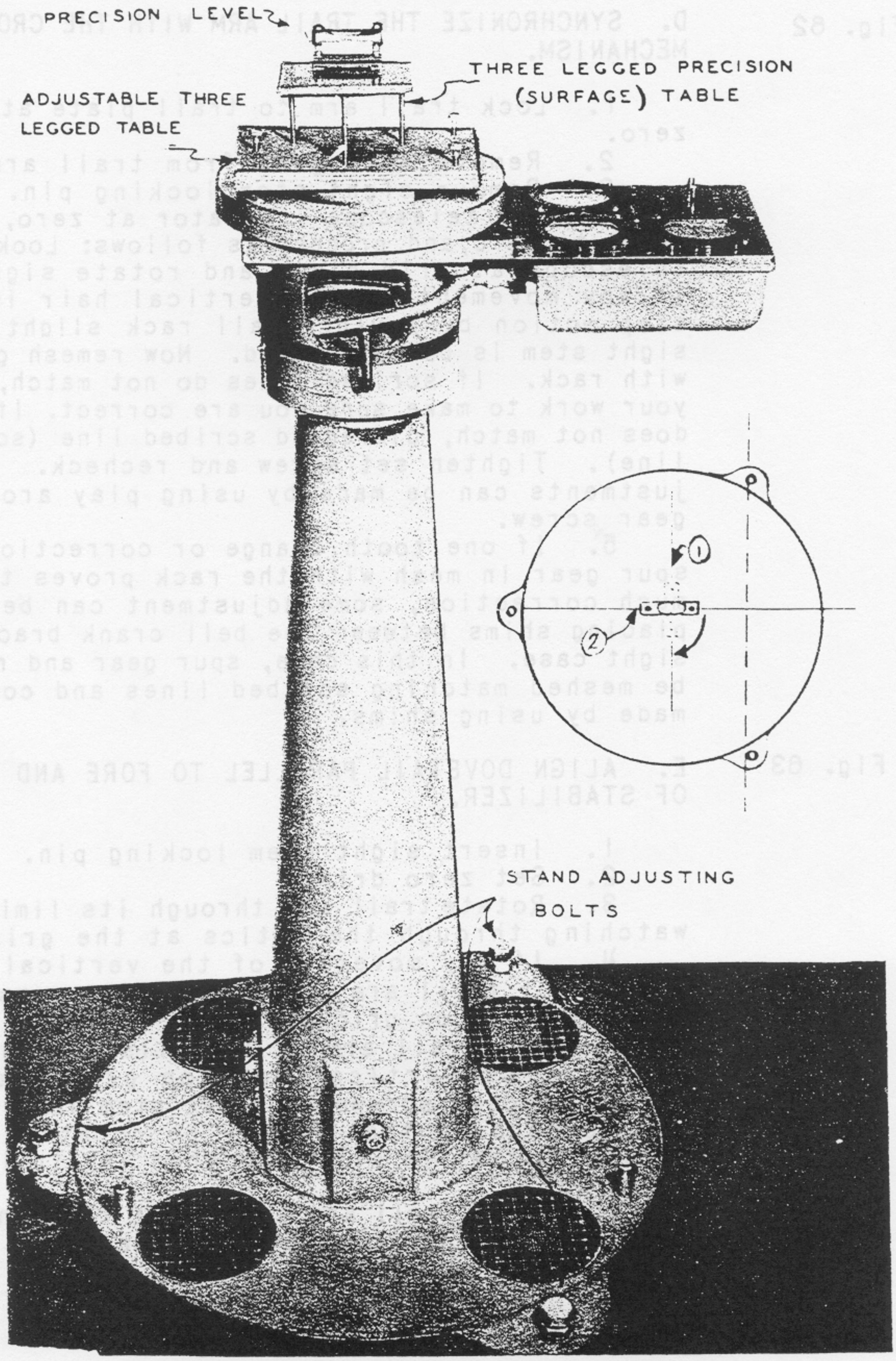

PRECISION LEVEL
THREE LEGGED PRECISION (SURFACE) TABLE
ADJUSTABLE THREE LEGGED TABLE
1
2
STAND ADJUSTING BOLTS

FIG. 64

amount it moved in step 5.

8. Tighten screws in sight stem locking plate and recheck your work.

F. PRECISION LEVEL. (CHECK PRECISION LEVEL FOR ACCURACY: TAKE SPECIAL PRECAUTION WHEN USING LEVEL NOT TO BREAK IT. NEVER PLACE LEVEL WHERE IT MAY ACCIDENTLY BE BROKEN. USE DRIFT PUNCH TO TIGHTEN TURRET NUTS. TIGHTEN FIRMLY BUT NOT ENOUGH TO BREAK GLASS). 6

1. Place adjustable surface plate on some solid base which is approximately level.

2. Level precision level by adjusting surface plate. Mark position of level on plate so that level may be positioned in the same place in relation to the surface plate.

3. Turn level 180° and note error.

4. Remove half the error by making adjustments on surface plate; remove other half of error by adjusting turret nuts on precision level.

5. Check by turning level 180°. If error is noted, repeat step 4.

6. Continue until 180° turn causes no error or causes equal apparent error.

7. Level must set on a perfectly true surface, free from dust.

Fig. 64 G. Level Head of stand. 7

1. Remove sight and stabilizer.

2. Place adjustable 3-legged table on head of stand.

3. Place 3-legged surface plate on table.

4. Using precision level, adjust table to bring plate horizontal.

5. Place length of bubble tube (on surface plate) parallel to a line between two mounting bolts in base of stand.

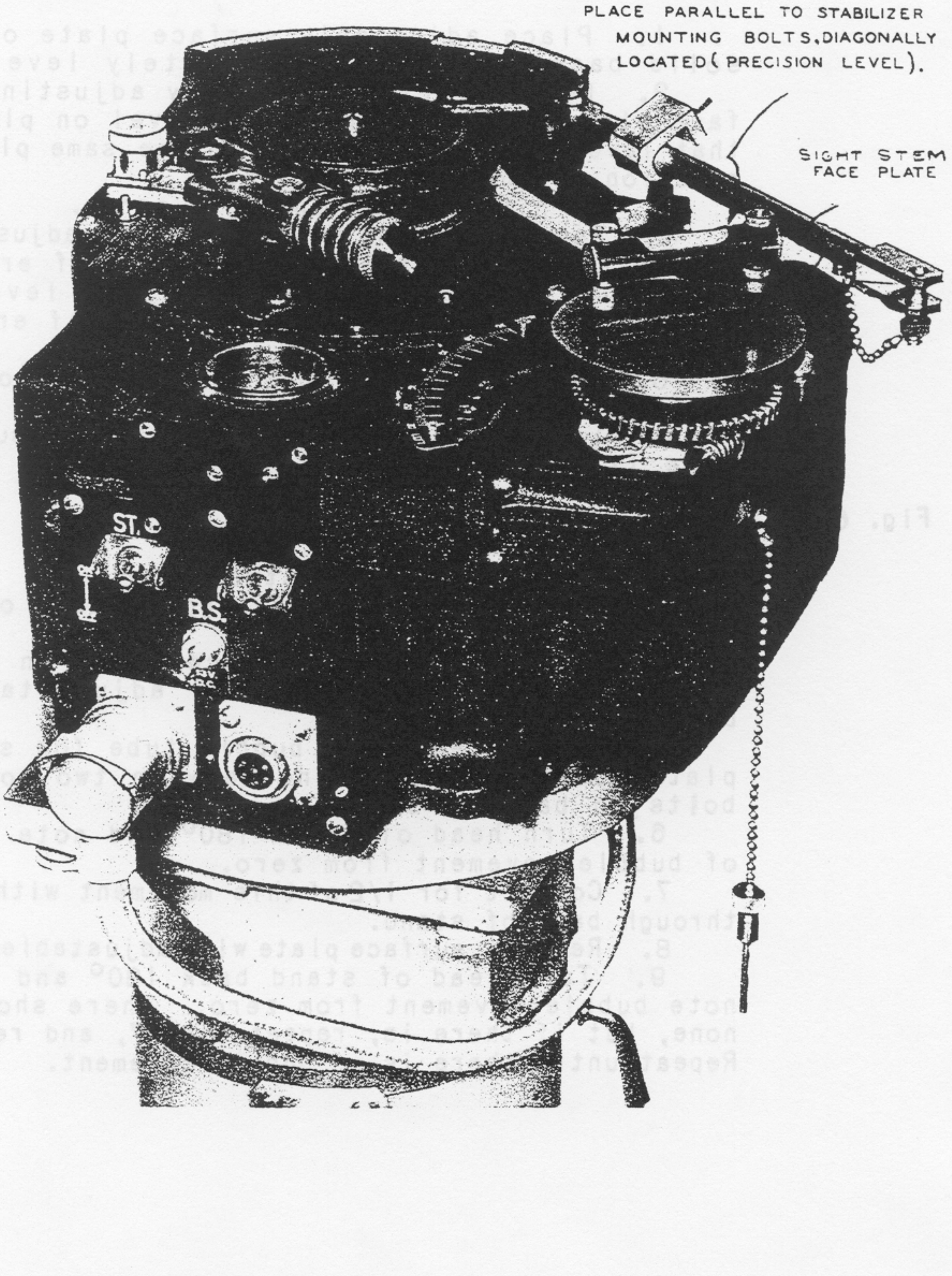
6. Turn head of stand 180° and note amount of bubble movement from zero.

7. Correct for 1/2 of this movement with bolts through base of stand.

8. Relevel surface plate with adjustable table.

9. Turn head of stand back 180° and note bubble movement from zero. There should be none, but if there is, repeat step 7, and recheck. Repeat until there is no bubble movement.

LEVEL STABILIZER


PLACE PARALLEL TO STABILIZER MOUNTING BOLTS, DIAGONALLY LOCATED (PRECISION LEVEL).
SIGHT STEM FACE PLATE
ST.
B.S.

10. Turn head of stand (90°) and repeat steps 4 to 9, inclusive. On 3-legged stands, leveling will not be done with the remaining leveling bolt. Stand should now be level, throughout 360°.

Fig. 65 H. LEVEL STABILIZER. 8

1. Mount stabilizer on head of stand.
2. Place sight stem surface plate in sight stem bushing.
3. Place precision level on plate and shim stabilizer until bubble will remain on zero as level is rotated throughout 360°. Level should be placed parallel with diagonal bolts.

I. MOUNT SIGHT ON STABILIZER.

1. Clamp directional connecting rod to pointer with course centering marks aligned. 9
2. Set zero drift.

Fig. 66 J. ERECT GYRO TO VERTICAL.

1. Allow gyro to warm up for approximately 60 minutes to reach operating temperature in order that gyro will be hot when gyro bubbles are checked for level.
2. Turn switches off, allow gyro to come to a stop, then remove upper half of sight housing.
3. Loosen cross trail clamp lever turret head screw just enough so that the telescope cradle may be tilted independently of the gyro but not so much that the cradle won't stay in any position in which it is placed.
4. Using wedges or clamps, fix gyro approximately vertical. Use bubbles as reference.
5. Place three-legged surface plate on top of gyro housing and precision level on surface plate.
6. Level surface plate by moving gyro on its bearings.
7. If wedges are used, tap very lightly on gyro when erecting it, using fiber drift, and also on wedges when driving them fast.
8. Be careful about surface plate. If wedges slip, surface plate and level will fall, probably doing much damage to themselves as well as to the sight.

K. CHECK GYRO LEVELING BUBBLES.

GYRO ERECTED TO VERTICAL

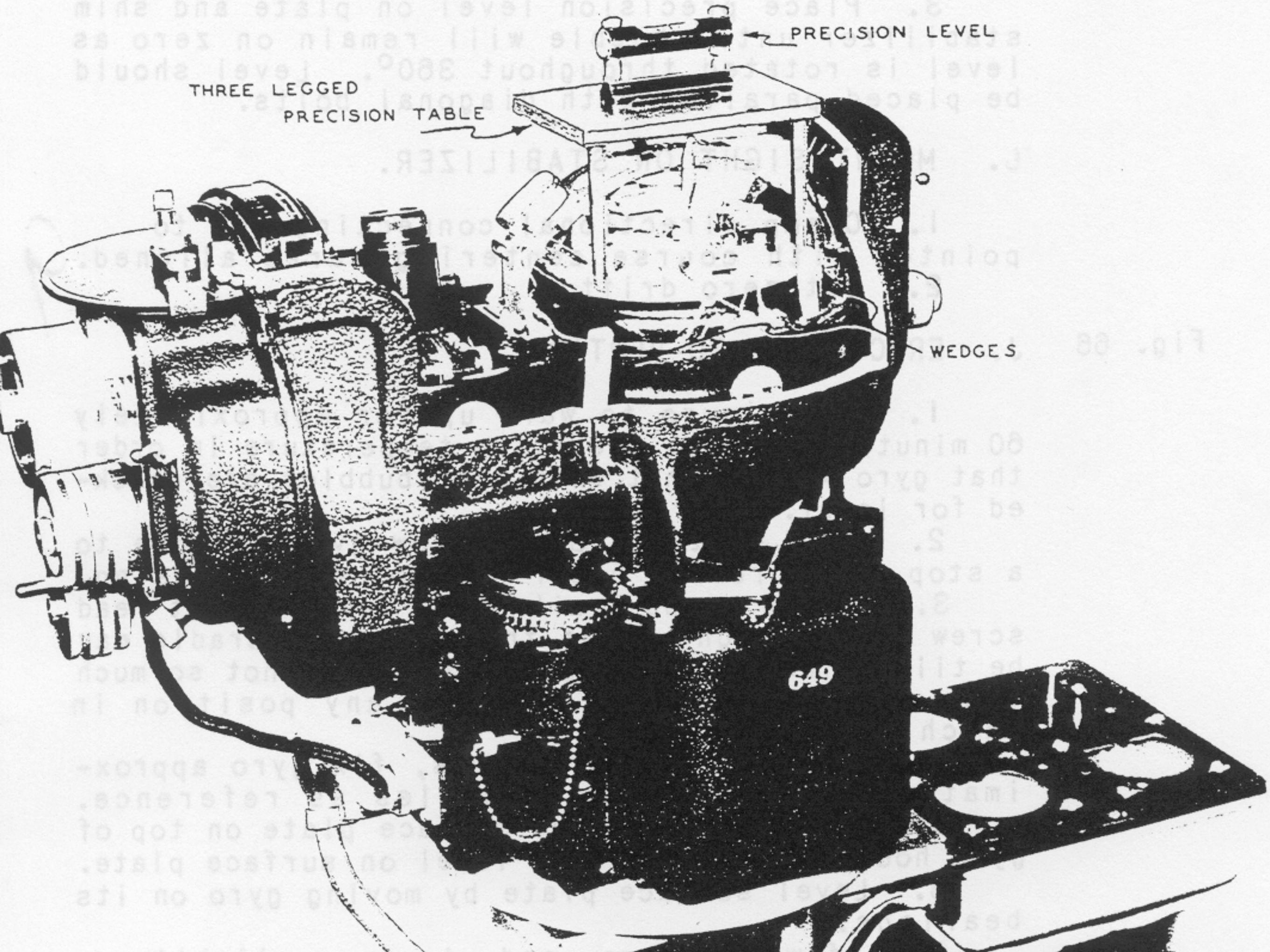


FIG. 66

1. With gyro hot and erected to the vertical, both bubbles should read zero. The bubble may be shimmed underneath the mounting brackets with paper, or in the case of a new bubble tube, the underside of a high side of the bubble may be stoned.

L. ERECT TELESCOPE TRANSVERSE CROSS HAIR TO THE VERTICAL. 10

1. Level small tripod mirror over center grid dowel pin (Grid has been removed).
2. With gyro in the vertical as in last paragraph, set telescope indicator to exactly zero.
3. Turn eccentric screw in #1 sheave until transverse hair bisects image of lower end of telescope tube in mirror.

Fig. 67

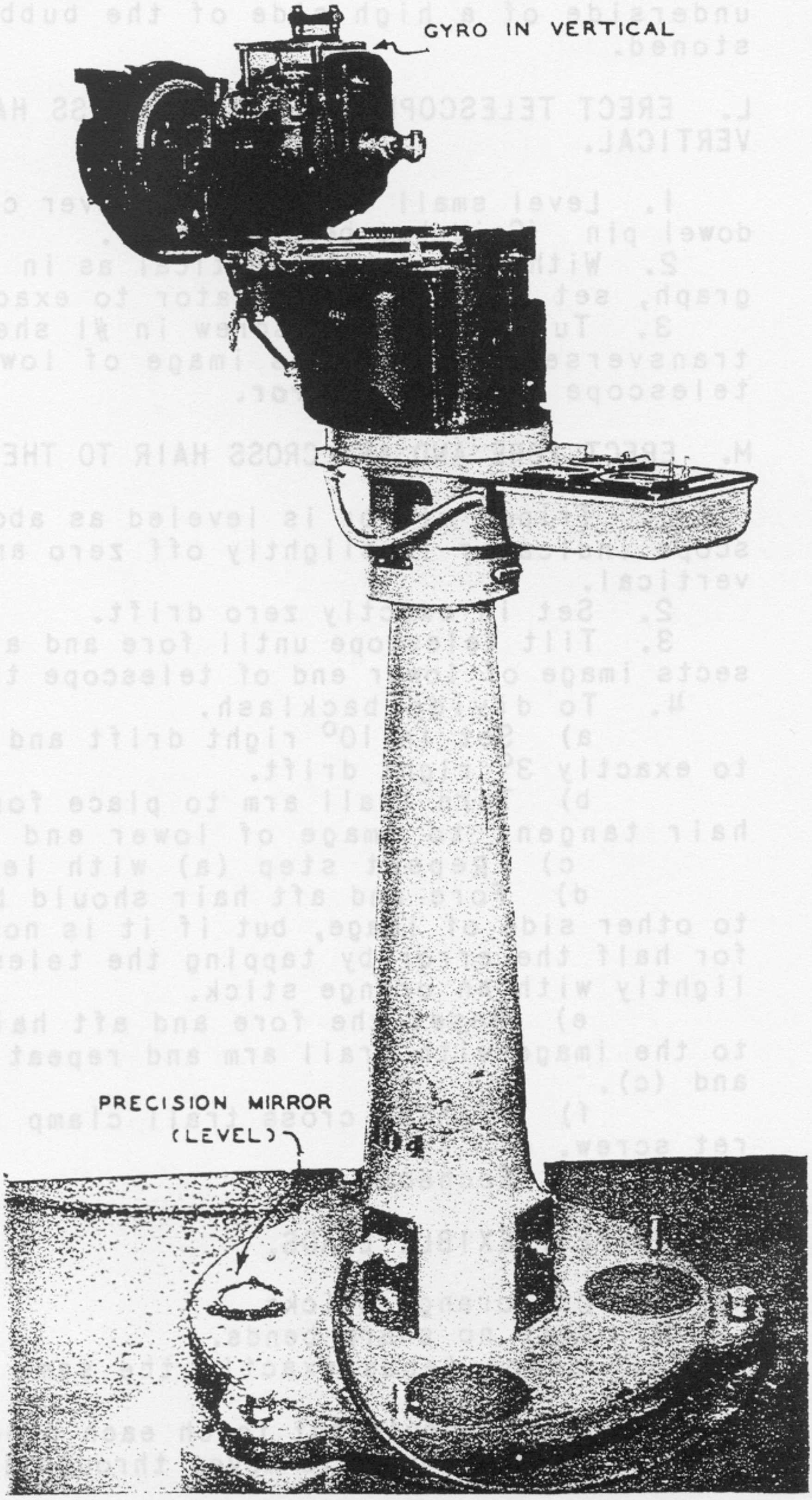
M. ERECT FORE AND AFT CROSS HAIR TO THE VERTICAL. 11

1. Tripod mirror is leveled as above, telescope indicator is slightly off zero and gyro is vertical.
2. Set in exactly zero drift.
3. Tilt telescope until fore and aft hair bisects image of lower end of telescope tube.
4. To divide backlash.
   - a) Set in 10° right drift and come back to exactly 3° right drift.
   - b) Turn trail arm to place fore and aft hair tangent to image of lower end of tube.
   - c) Repeat step (a) with left drift.
   - d) Fore and aft hair should be tangent to other side of image, but if it is not, correct for half the error by tapping the telescope tube lightly with an orange stick.
   - e) Reset the fore and aft hair tangent to the image with trail arm and repeat steps (a) and (c).
   - f) Tighten cross trail clamp lever turret screw.
   - g) Recheck.

N. SHAPE FLEXIBLE LEADS. 12

1. Use orange sticks.
2. Make no sharp bends.
3. Shape leads exactly the same (in each set).
4. Leads should not touch each other or anything else, when gyro is moved through its limits.

ERECTION OF OPTICS TO VERTICAL



13

O. PRECESSION CHECK: BEFORE MAKING A PRECESSION RUN ALL PREVIOUS STEPS IN CALIBRATION MUST BE PERFORMED.

1. Check flexible leads, pigtails and all other wiring in gyro.
2. Work all gudgeon bearings to distribute oil and to insure freedom.
3. Let gyro run for 60 minutes to attain running temperature (140° F.).
4. Set zero drift and place sight on one cardinal heading.
5. Before starting each run, uncage gyro and spiral cross hairs to center of grid with leveling knobs, making last movement always in same direction.
6. Start stop watch and plot for two minutes. Repeat this on opposite heading.
7. From these two readings, determine in which direction the weights must be moved to obtain proper apparent easterly precession for this latitude. One method of determining which way the weights on top of gyro should be moved is: to adjust for lateral or transverse precession, move the weights on the longitudinal or fore and aft screw. Move the weights forward if the cross hairs precess to the right. Move the weights to the rear if the cross hairs precess to the left. To adjust for fore and aft precession, move the weights on the transverse screw. Move weights to left if cross hairs precess forward. Move the weights to the right if the cross hairs precess rearward. When moving weights, always count the number of turns givem. This will give an approximation of the amount needed to turn the weight for a desired change in precession. Make another run as in steps above N.O.P. #650
8. When apparent easterly precession is close to the same on the two headings above for two minute runs, take two minute runs on the other two headings (easterly precession). When easterly precession is approximately equal for the four headings, take four minute runs for fine adjustment.

Disregard north hook when making adjustment; it will be corrected automatically as easterly precession is adjusted. If north hook is excessive, or not approximately equal on all headings, it probably indicates that the bearings need cleaning.

Precession Check Of Stabilizer Gyro.

1. Level stand.
2. Place stabilizer on stand.
3. Turnon stabilizer gyro and let it warm up for thirty minutes.
4. Turn on torque motor.
5. Clutch in auto-pilot clutch with stabilized brush on zero.
6. If the gyro does not precess any noticeable amount in 15 minutes, it is all right. If it precesses more than 1° per hour (stabilized brush moves off zero) rebalance as follows. If it precesses clockwise, looking from the top, remove some weight from the end opposite the commutator and vise-versa. CAUTION: Do not loosen the field retaining screws. Do not lose spacer, under bearing cap.

SECTION XI

REVIEW AND REFERENCE INFORMATION

CONFIDENTIAL LETTERS OF INSTRUCTION.

A. Purpose:

Confidential letters of instruction are sent to this department and to the units working in the field for the purpose of acquainting the maintenance men with newer methods, techniques, and information concernigg the units on hand. These confidential letters of instruction, better known as C.L.I., are confidential and must be treated with the respect due confidential documents.

B. Method of Numbering:

In looking up a confidential letter, one may find it marked as follows: (N) -41-17A. In interpreting this marking, one finds that the following is true: The (N) means that the letter refers to Norden equipment; the 41 means that the letter was received in the Army fiscal year, 1941; the 17 means that the letter was number 17 received in that fiscal year (fiscal year dates from July 1st to 30th); the A following the 17 means that it is a supplement to letter number 17 and may rescind a part of or add to 41-17.

C. Confidential letters remain in force until rescinded, corrected or replaced.

C.L.I. with which students should be familiar are as follows.

40-3	Interchangeability in airplanes.
B-40-12	Interchangeability of sight and stabilizer.
B-41-2	Type Designation of M-Series Bombsights.
C-42-24	Interchangeability of Bombsights in Bombardment Airplanes.
C-42-28	Care of Bombsights and Allied Equipment Following Water Immersion.
A-42-18	Stabilizer Mounting Screws, M-Series Bombsights.
B-42-30	Modification of Mirror Tilting Device M-4, M-5. M-6, M-7 Bombsights.
B-42-31	General - Use and Storage of Bombsights.
B-43-5	Calibration of Altitude Knob.
B-43-12	Calibration of M-Series Bombsights
B-43-13	Destruction of Confidential Equipment in Combat Zones.
B-43-20	Discontinuance of Automatic ERection System.

B-43-23	Cleaning and Preservation of Bombsights
B-43-26	Automatic Release Mechanism-Installation and Operation Of.
C-43-9	Dustproofing of M-Series
C-43-14	Care and Inspection of Bombsights and Type B and C Automatic Pilot(AFCE) while in Storage.
C-43-27	Cold Weather Operation and the Use of Heating Covers on M-Series Bombsights
M-43-15	Bombsight Storage.

TECHNICAL ORDERS

A. Technical orders deal with operation, maintenance or any type of instruction that is considered "Restricted" rather than "confidential". (Technical order 11-30-5 discusses the operation, maintenance and calibration of the D-8 sight).

CALIBRATION TOOLS

Precision Surface Plates and Tables

Precision surface plates and leveling tables provide a true surface which may be used as a reference and provide a precision surface upon which the precision level may be leveled.

Precision Level

PRECISION LEVEL. The precision level is used to level the stand, stabilizer, vertical gyro and the precision mirror.

The precision level consists of two parts, capable by turret nut adjustments of changing their relationship to each other. First there is the glass tube containing the liquid with its bubble. Then there is the base.

The level has been properly leveled when the base is perfectly parallel to the glass.

The procedure to accomplish this is to place the level upon the adjustable three-legged table. (Actually a precision table is inserted between the two, but it has no significance other than to provide a perfectly flat surface). Then the thumb screws of the adjustable table are rotated until the bubble is centered. Now two things are true: (1) the glass is perfectly horizontal and (2) insofar as the base is not it has exactly the same amount--but opposite--of error in it as has the adjustable table. By positioning the precision level about 180°, we find out how much this error is and are also in a position to remove one-half of it with the level and the other half with the table. When the level has been turned about 180°. the error in the level is now not only equal with that in the table but also they are the same and not opposite errors. If exactly one-half of the error were removed with the level and the remaining one-half with the table, then there would be no need of again turning the level about 180°.

The level should be checked for accuracy from time to time by positioning it on a true surface about 180°; if the level is accurate, the bubble should be off exactly the same amount in each case.

Precision Mirror

The precision mirror is used for the reflecting surface to erect the optics. The mirror must be level and is used only in shop calibration.

Tachometer

Speed indicator (tachometer) is used to determine the revolutions per minute (rpm) of revolving motors and shafts, Follow these instructions in using a tachometer.

(a) Place the tip of the drive shaft of the indicator against the center of the shaft arbor or spindle of machine under test, so axis of each coincides within reason.

(b) Press the Push Button full depth and release it quickly.

(c) When pointer stops, read the result in revolutions per minute.

(d) Allow at least 5 seconds between trials.

NOTE:

The last reading should remain on the dial until the Indicator has been placed in position on the machine under test for a new reading, pressing the Push Button as before. A full push of the Button resets the counting mechanism, winding the time element, and a quick release starts the escapement instantly. The escapement button should NEVER be depressed unless in the act of obtaining a reading.

LUBRICATION:

Oil the shaft occasionally with a good grade of watch oil through hole provided. The movement should not be tampered with except by experienced instrument repair men.

Stop Watches

Stop watches and interval timer clocks are special devices for measuring specific periods of time. It is necessary in checking and adjusting the bombsight equipment to make use of these measuring devices. Handle them with extreme care, and do not tinker with the mechanism.

.969 Guage.

This guage is used to determine whether the movable weight on the A.E.S. is centered. Place guage between movable weight and lead screw bearing bracket.

REASONS FOR VARIOUS STEPS OF CALIBRATION

A. Set pedestal reference index.

1. Pedestal reference index is determined to align the plane of rotation of the point of intersection of the cross hairs with compass heading of the grid lines.

a. Set zero drift in order to remove any cross trail tilt in the optics.

(1) A tilt in the optics would change the compass heading of the plane of rotation of the cross hairs.

2. When "1" is accomplished, set the pedestal reference index so that using it as a guide the sight and stabilizer may be positioned accurately to either side 90° or around a complete 180°.

B. Establish grid lines on true heading.

1. In "A" above, the plane of rotation of the point of intersection of the cross hairs is aligned with the compass heading of the grid lines (and the sight and stabilizer are fixed to the stand in this position so as to maintain this relationship). Maintaining this relationship, rotate the base of the stand until the grid lines (and therefore the plane of rotation of the point of intersection of the hairs) are aligned with one of the cardinal headings).

a. Steps "A" and "B" are not necessary except for precession runs.

(1) Step "A": makes it possible to switch quickly from one cardinal heading to another.

(2) Step "B": If precession runs are made on cardinal headings, either--but not both--the gyro gudgeon bearings or the cardan gudgeon bearings will tilt as a result of apparent easterly precession. By using only one set of bearings at a time, it is possible to approximate standard figures for easterly precession and north hook. If the sight were not on a cardinal heading, both sets of balancing weights would have to be used in order to make corrections, and it would be impossible to calculate how much to rotate each weight.

C. Check Alignment of Vertical Cross Hair.

1. This check determines whether the plane of rotation of the optics is along the same compass heading as the fore and aft cross hair.

a. This must be or it would be impossible to set up course. The optics must be driven along the same heading as that of the fore and aft cross hair or the latter will drift off the target.

b. Test may be made with tilt in optics because regardless of the amount of tilt, this relationship between the plane of mirror rotation and the plane of rotation of the fore and aft cross hair remains exactly the same.

D. Synchronize the Trail Arm With the Cross Trail Mechanism.

1. PURPOSE: To have the eccentric stud positioned at exact center of the sight stem with the trail arm resting at zero mils.

a. When the trail arm is positioned, trail is set in the trail mechanism and the cross trail mechanism. The trail arm is set off from zero. but trail in the C.T. mechanism will not be set in from zero unless the eccentric stud is centered when the trail arm is at zero.

b. When the sight stem locking pin is removed and the sight stem rotated, no tilt in the optics will occur if the eccentric stud is centered.

E. Align Dovetail Parallel to Fore and Aft Axis of Stabilizer.

1. The dovetail must be aligned parallel to fore and aft axis of stabilizer or else with zero drift (no cross wind) there will be a cross trail tilt of the optics occasioning a deflection error.

2. When the dovetail is aligned, with zero drift, moving the eccentric stud backward and forward does not cause any tilt in the optics. The optics will tilt if the dovetail is misaligned or zero drift is not present AND if trail is set in the C.T. mechanism.

F. Precision Level.

1. The precision level consists of two parts, capable (by turret nut adjustment) of changing their relationship to each other. The component parts are the glass tube, containing the liquid and bubble, the adjusting nuts and the base.

2. The level has been properly leveled when the base is perfectly paralled to the glass.

3. The procedure to accomplish this is to place a 3-legged precision table on a 3-legged adjustable table, and then the level upon the 3-legged precision table. The thumb screws of the adjustable table are rotated until the bubble is centered. Now two things are true: (1) The glass is perfectly horizontal and (2) insofar as the base is not, it has exactly the same amount, but opposite error in it as has the adjustable table. Turning the precesion level 180° is a means of

determining this error, and it is also in a position to remove one-half of the error with the level and the other half with the table. When the level has been turned about 180°, the error in the level is now not only equal with that in the table but also they are the same and not opposite errors. If exactly one-half of the error were removed with each the level and one-half with the table, then there would be no need of again turning the level about 180°.

4. The level should be checked for accuracy from time to time by positioning it on a flat surface and turned 180°; if the level is accurate, the bubble should be off exactly the same amount in each case. Always mark first position of level on table and always place on same spot when turning it 180°.

G. Level head of stand.

1. The aim is to make the plane of rotation of the head of the stand exactly in the horizontal.

a. If it were not, when the sight was changed from one cardinal heading to another while making precession runs, the point of bearing contact would be changed. Since bearings are not perfect, this might result in different readings.

b. Many maintenance men omit this step as one of minor consequence. However, it is briefly accomplished and should be included. One leveling can last for numerous calibrations.

H. Level Stabilizer.

1. Our aim here is to erect the sight stem bushing to the true vertical.

a. This step is necessary in connection with precession runs and in the division of backlash when using one of the reflection methods in the erection of the cross hairs.

I. Wedge Gyro in The Vertical--Procedure.

1. With no tilt in the C.T. mechanism, the gyro and fore and aft hair should occupy the same relative position to the vertical. This is because the fore and aft hair should at all times be in the vertical except for any tilt occasioned by the C.T. mechanism independent of the gyro. The gyro is always retained in the vertical by centering the gyro leveling bubbles--and it must then be assumed, if deflection error is to be avoided. that the fore and aft hair is also in the vertical except as mentioned.

2. First wedge the gyro in the transverse plane, that is, wedge the gyro housing so as to remove all tilt.

   a. Select two thin or slim wedges for this purpose. Wedges should be free of indentations.

3. Use the gyro bubbles as a guide. Do not yet employ the precision level.

4. Position the wedges firmly; but this will be done by a considerable number of light taps with a mallet rather than by a few heavy blows.

5. Use a long slender fiber drift and mallet to tap the gyro housing (if erecting in the fore and aft plane). Again make certain a considerable number of light taps are employed rather than a few heavy blows.

   a. This tapping will be done to center the gyro bubbles.

6. Only after the transverse bubble has been centered will the attempt be made to erect the gyro in the fore and aft plane.

   a. Wedges for this purpose will be thicker.

   b. After this operation is complete, determine whether the transverse bubble is still centered.

7. The precision level may now be used.

   a. Mount the 3-legged precision table upon the gyro housing. Upon it place the precision level (previously leveled) so that it will give a reading for the transverse plane.

   b. Using fiber drift and mallet, tap gyro housing lightly until the bubble of the precision level is centered.

   c. Check constantly to determine whether the precision level is actually level by turning it 180°; the bubble should occupy the same relative position in each case.

   d. Turn the precision level 90° so that it reads in the fore and aft plane. Follow the same procedure.

   e. Finally turn the precession level back 90° so that it reads in the transverse plane and check to see that the bubble still remains centered.

J. Erect Telescope Transverse Cross Hair To The Vertical.

1. The object is to position the transverse hair in relation to the gyro with the gyro vertical; that is, with the gyro in the vertical and

the telescope quadrant at exactly zero, the transverse hair should be exactly zero. This relationship must exist because otherwise the position of the telescope quadrant from its zero degrees setting will not be exactly the same as the sighting angle in degrees. And this would mean range errors.

2. To displace the transverse hair:

a. It has been found best to leave the rate end on, remove the inspection plate, and slightly rotate (open) the optics until the screwdriver can reach the eccentric screw.

K. Two Things Must Be In Proper Relationship To Each Other In The Erection Of Either Hair To The Vertical.

a. First there is the image of the lower portion of the telescope tube. (Use rear image for models later than M-3). This image is always found upon the precision mirror at a point where a line drawn perpendicular to the precision mirror from the lower portion of the telescope tube (or its reflection from the rotating mirror in the case of models later than M-3) intersects the precision mirror.

b. Second, there is the matter of aiming along the cross hair in exactly the same manner one aims a gun. The cross hair is analogous to the front gunsight. It is not reflected.

(1) There are here two points of reference: (1) the position of the eye and (2) the position of the cross hair. The eye should be positioned along the axis of the telescope tube. Peep sights are used to facilitate this. The fore and aft cross hair is positioned by tilting the optics laterally; the transverse cross hair is positioned by opening and closing the optics.

(a) In this paragraph, the discussion will be limited to the M-3 and earlier series. The telescope tube will be moved about until the line of sight established by the position of the cross hair being erected exactly divides the image. When this is finally accomplished, the telescope tube will be found to be at right angles to the mirror. The cross hair has then been erected to the vertical--PROVIDED the precision mirror is horizontal. Suppose the precision mirror was not horizontal. The telescope tube will still take a final position at right angles to the surface of the precision mirror. BUT naturally it will not then be in the vertical,

(b) The discussion is limited to series later than M-3. The telescope tube on these series cannot move in the fore and aft plane. They can be moved laterally and therefore all that has been said in the preceding paragraphs applies to the erection of the fore and aft hair of these later series. And what has been said in the preceding paragraph also applies to the erection of the transverse hair of these later series provided that it be understood it is the line of sight along the transverse hair as reflected that it is being sought to erect to the vertical.

DEFLECTION AND RANGE ERRORS

It has been stated that if the bombsight were accurately calibrated and the bombardier properly synchronized that the bomb would hit the target. However, unless the above is true there will exist bombing errors. Some of the bombing errors most frequently encountered are caused by incorrect calibration and setting in of bombing data.

The deflection and range errors given below are not all the possible errors but those most frequently encountered.

DEFLECTION ERRORS

A. Definitions

Where the bomb strikes to either side of the collision course, the bombing error, to that extent, is a deflection error "right" or "left". Where the bomb strikes to either side of a line perpendicular to the collision course and which intersects the target, the bombing error, to that extent, is a range error "over" or "under". A bombing error which is a combination of a deflection error and a range error is called a circular error.

B. Causes of Deflection Errors

Normally deflection errors are attributable to a tilt in the optics which is incorrect (either too great or too small) for the given conditions. However, deflection errors may occur either because the equipment is so faulty it is impossible to "set up" the proper course or else because the operator's technique is so faulty that he cannot "kill drift".

C. Prerequisites For Under-Standing of Deflection Errors

A thorough understanding should be had of the construction and operation of the cross trail mechanism. Any transverse movement of the cross trail carriage in relation to the bombsight case will cause a tilt of the telescope cradle.

The transverse movement of the cross trail carriage, in relation to the bombsight case, will occur when the azimuth heading of the sight and stabilizer change in relation to each other. Thus if the plane turns in azimuth independently of the sight, or the sight is turned independently of the plane, the cross trail carriage (and optics) will move.

The construction and operation of the course knob assembly and how the fore and aft hair is stabilized in azimuth should be understood. The stabilizer gyro through the bombsight clutch stabilizes the stabilized sector in azimuth. The stabilized sector is meshed with the turn worm (a part of the course knob assembly), and imparts its stabilization to the turn worm. Since the turn worm is an integrall part of the bombsight case, the entire bombsight is stabilized in azimuth.

As regards course there is the relationship between three distinct azimuth headings that should be known. First there is the azimuth heading of the longitudinal axis of the plane. Second there is the actual line of flight of the plane. This latter is also the ground track. The angle between these two azimuth headings is of course the drift angle. Third there is the azimuth headings of the fore and aft hair, i.e. azimuth heading of the line of sight. If the azimuth heading of the line of sight is not exactly the same as that of the line of flight, then drift is still present and before a course can be set up and HELD it is necessary to "kill drift". In every case the azimuth heading of both the line of sight and the line of flight must be the same or parallel.

Causes of Deflection Errors:

A. Dovetail Misaligned

The dovetail is misaligned when its fore and aft axis is not parallel to the fore and aft axis of the stabilizer. With zero drift the transverse axis of the bombsight case will be at 90° to the fore and aft axis of the stabilizer. Naturally with zero drift reading, there should be no tilt in the optics. With the trail setting in the C.T.

mechanism, there will be a tilt in the optics if the dovetail is misaligned. That is, the eccentric stud will not move rearward parallel to the fore and aft axis of the stabilizer; it will move to either side of this axis and consequently to that extent it will carry the C.T. carriage to either side and thereby tilt the optics.

A clockwise misalignment of the dovetail causes a right bombing error and a counter clockwise misalignment causes a left bombing error.

B. Eccentric Stud Not At Exact Center of the Sight Stem With Trail Arm At Zero Mils.

When the trail arm is rotated, the eccentric disc, and with it the eccentric stud, are displaced rearward. If the trail chart for the given bombing problem calls for 50 mils trail, the eccentric disc, after the trail arm has been set at 50 mils on the trail plate, should rest to the rear of center of the sight stem the exact distance for 50 mils. If the eccentric stud did not rest at exact center of the sight stem when the trail arm was at 0 mils, then when the trail arm is positioned to 50 mils the eccentric stud will not rest the distance to the rear of the sight stem that corresponds to 50 mils.

If the eccentric stud rested to the rear of the center of the sight stem when the trail arm was at 0 mils, excessive trail will result in the cross trail mechanism.

Excessive trail in the cross trail mechanism will always give an upwind error. Too little trail in the cross trail mechanism will always give a downwind error.

C. Misalignment of Stabilizer.

The stabilizer is misaligned when its fore and aft axis is not parallel to the fore and aft axis of the plane.

Even with the stabilizer misaligned, if there is zero drift, that is, if the transverse axis of the bombsight case is exactly at 90° to the fore and aft axis of the stabilizer, there will be no tilt in the optics.

If the stabilizer is misaligned, when the fore and aft hair is made parallel to the fore and aft axis of the plane, there will be a drift reading. And the presence of drift will, of course, result in a tilt in the optics. This tilt, which should not be present, will cause a deflection error.

If the stabilizer is misaligned clockwise, the bottom of the optics will be tilted to the left and the deflection error will be to the right. If the stabilizer is misaligned counter clockwise, the bottom of the optics will be tilted to the right and the deflection error will be to the left.

D. Failure to Erect Fore and Aft Hair Properly.

If the fore and aft hair does not rest in the vertical with zero drift and zero trail in the C.T. mechanism, a deflection error will occur. This would be true even though the gyro rested in the true vertical at the time the hair was being erected. If the gyro were out of the true vertical in the same direction and for the same amount that the fore and aft hair was improperly erected, then there would be no cause for a deflection error.

One of the most common causes for improper erection of the fore and aft hair is failure to have the reflecting surface level.

Even though the fore and aft hair were erected to the vertical with zero drift and zero trail in the C.T. mechanism and while the gyro was in the true vertical, if at this time the transverse bubble is not centered, a bombing error is bound to occur in actual operation of the sight. This is true as long as the leveling bubbles are used and there is no automatic erection system capable of constant operation. The student should be able to state the kind of bombing error which would occur; first, if the transverse bubble in this case rested to the right; second, if it rested to the left of center.

E. Reticle Out of Alignment.

The reticle is out of alignment when the compass heading of the fore and aft hair is not exactly the same as the compass heading of the plane of rotation of the optics--of the mirror in case of the M-6.

The students may engage in discussion relative to the extreme difficulty in setting up a course--in fact it would be a practical impossibility. They should also consider both clockwise and counter-clockwise misalignment of the reticle relative to the nature of the deflection error which would most likely occur.

Range Errors

A range error is caused by improper time of bomb release.

For any given altitude, velocity of closure, airspeed (CIAS) and trail value of the bomb, there is but one correct point (i.e. time) of bomb release.

The Norden Bombsight is constructed so that the point of bomb release occurs when the index of the telescope quadrant coincides with the index of the rate quadrant. For purposes of discussion, assume this to be the same as when the oncoming telescope quadrant meets the stationary rate quadrant. It is at this point that the automatic release points are closed.

In the Norden Bombsight the time of bomb release depends on three things:

1. The position of the rate quadrant.
2. The speed of drive of the telescope quadrant.
3. The position of the telescope quadrant relative to the position of the transverse hair.

QUADRANTS DRIVING TOWARD RELEASE

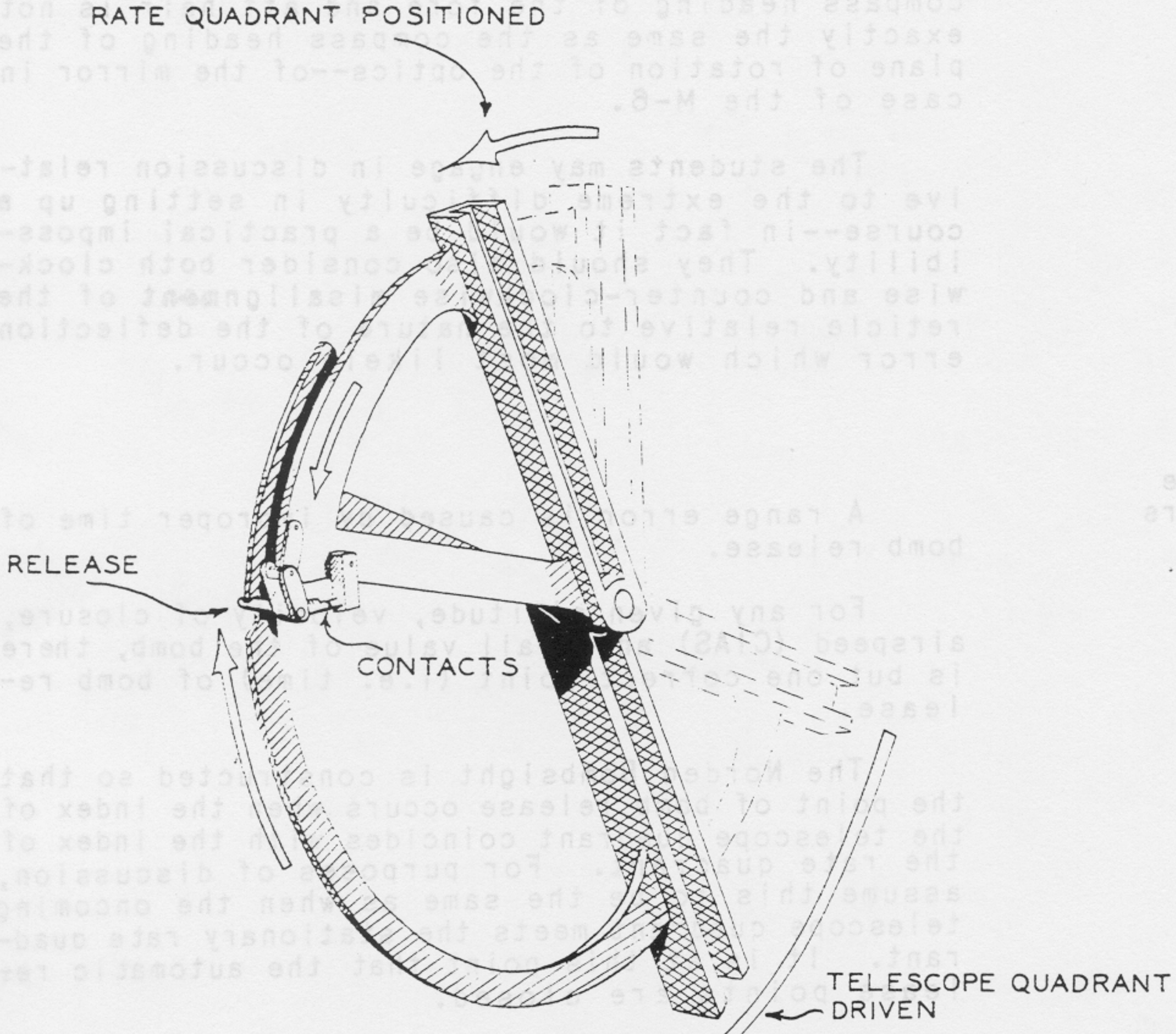


FIG. 68

In Fig. 68. the three relationships upon which time of bomb release depends are shown. The rate quadrant does not drive. It is moved from zero tangent function counter clockwise simply by rotating the rate knob, and when moved counter clockwise it will assume a position (stationary, when rate knob action ceases) closer to the oncoming telescope quadrant. The telescope quadrant is moved from zero sighting angle to maximum sighting angle by moving the telescope quadrant counter clockwise. The counter clockwise movement of the telescope quadrant is accomplished by rotating either the displacement or search knob. The telecope motor will drive the telescope quadrant only in a clockwise direction, i.e. toward the rate quadrant or toward zero.

Causes of Range Errors.

A. Causes of Improper Positioning of Rate Quadrant.

1. Roller not zeroed, i.e. roller above or below disc center with zero rate and zero trail.
   a. After trail has been set in, the roller will rest higher (if above center) than it should upon the disc. The rate mechanism then takes the roller up the rest of the distance to point of synchronization. If the roller were above center of the disc (with zero value for trail and rate). the displacement of the roller by the rate mechanism will be less than it should be and will therefore not bring the rate quadrant downward toward the oncoming telescope quadrant as far as it should, and therefore a later release results. The bomb will not strike the target; there will be an "over". If the roller were below the center of the disc (with zero value for trail and rate), the displacement of the roller by the rate mechanism would have to be more to place the roller at the point of synchronization and thereby position the rate quadrant at a great-

er tangent value. The bomb will be released too soon and a "short" would result.

2. Worn Roller.
   a. When trail has been set in, the roller will rest upon the disc the proper distance upward for trail. But since the roller is of smaller circumference, it obtains its necessary R.P.M's for synchronization at a lower point on the disc. This means the rate mechanism is displaced less (used less) than it should be, and this means that the rate quadrant is not at the correct dropping angle for the given altitude, velocity of closure, and trail value of of the bomb. The result is an "over".

3. Slipping Roller.
   a. As in "2 there is no difficulty with trail, but since the roller slips, in order to obtain the necessary roller R.P.M's to synchronize, the roller will have to be raised higher up on the disc than otherwise. The result is excessive use of the rate mechanism, and the rate quadrant will have been brought downward too far toward the oncoming telescope quadrant.
      (1) This is one of the three cases in which it is impossible to synchronize. This is only because roller slippage is never at a constant rate; it increases as the optics approach zero degrees because of increasing tension on the telescope mirror return spring.

4. Incorrect Disc Speed.
   The correct roller R.P.M.'s for synchronization will be obtained with the roller either too high (too low a disc speed) or too low (too high a disc speed) upon the disc. Thus, either too much (for too low a disc speed) or too little (for too great a disc speed) use of the rate mechanism is occasioned.

B. Incorrect Speed of Drive of Telescope Quadrant.

1. This can occur if the unit is properly calibrated or it can occur because the unit is improperly calibrated. If the former, it is the operator's fault: he has failed to use his rate correctly and not synchronized. Thus, he will use either too much or too little rate, and therefore the rate quadrant will also be incorrectly positioned. If he puts in too much rate, not only will the telescope quadrant drive too fast but also the rate quadrant will be positioned downward too close to the telescope quadrant, both errors causing, by cumulative effect, an early release. Just the opposite is true for too little rate.

2. How miscalibration can cause too fast or too slow a rate of drive of the optics, that is, of the telescope quadrant, will be seen from point "C" below. The important thing to remember is that incorrect speed of drive of the telescope quadrant never exist alone; it is always accompanied by the error in "A" or "B".

C. The Position of the Transverse Hair is Out of Relationship to the Position of the Telescope Quadrant.

1. The transverse hair should be at vertical when the telescope quadrant is at zero. If it be, say, 3° forward of vertical, then if the sighting angle happens to be 40°, the telescope quadrant will be positioned at 37°. In other words, the telescope quadrant would have to move only 37° from its initial zero degrees position in order that the transverse hair, which begins 3° forward of vertical, rest upon a target 40° away. If the actual sighting angle be 40°, then of course the telescope quadrant should then be at 40°. This erroneous position of the quadrant (notice that the optics cannot be said to be at an erroneous position because they have to be open to the true sighting angle to rest upon the target) causes too early a bomb release for two reasons: (1) first the telescope quadrant is positioned 3° too close

to the rate quadrant and for that reason would arrive at the set actual range angle position of the rate quadrant too soon; (2) second, because of the acceleration of the rate of drive of the telescope quadrant, it will be traveling too fast toward the rate quadrant; that is, the sighting angle changes more slowly at 40° than at 37°, but the optics are being driven at a rate for a 37° sighting angle.

2. The same reasoning leading to an opposite conclusion is followed where the optics are to the rear of vertical when the telescope quadrant is at zero degrees.

3. When the position of the transverse hair is out of relationship to the position of the telescope quadrant, it is obvious that the optics will not be driven toward vertical at the same rate that the sighting angle changes. This is because of the acceleration of the rate of drive of the telescope quadrant. The quadrant will drive at the same rate as the sighting angle changes only when it is set the same as the sighting angle. Therefore, this is another of the three cases in which synchronization is impossible, and it is the most important example. The remaining example is that of erratic disc speed.

4. The transverse hair may be in the vertical with the telescope quadrant at zero, and yet when the optics are being opened toward maximum sighting angle, the transverse hair may get out of relationship to the telescope quadrant. This will occur only when a piece of foreign matter is on one of the sheaves and it begins to contact the cable when the optics are opened up to that point, or it will occur where there is a kink in the cable and only then when that kink begins to contact one of the sheaves. The transverse hair should always be at exactly the same setting as the telescope quadrant throughout the entire range of the telescope quadrant.

BEAM AND TAPE

A. Reason for Use.

In this procedure the purpose is to simulate the flight of the plane at a certain speed, altitude and using a certain bomb of a given A.T.F. The bombsight is actually used in this test exactly the same as on a bombing run to determine exactly where the rate quadrant will be positioned under the given data; and to demonstrate how the bombsight solves the bombing problem mechanically. Then the same problem is worked out mathematically to determine exactly at which position the rate quadrant should be for those circumstances. In this way, it can be determined whether or not the rate end is solving the bombing problem correctly.

B. Set Up Beam And Tape.

1. Level stand and stabilizer.
2. Wedge gyro to true vertical.
3. Check vertical of optics.
4. Level beam.

1000 mil method of leveling beam:

Set telescope indicator at exactly zero. Slide steel scale on beam so that the zero of the beam comes underneath the transverse hair. Set telescope indicator at exactly 45°. Raise or lower the end of the beam until the 1000 mil mark on the steel scale comes exactly underneath the transverse hair.

C. Model Problem and Mathematical Solution.

1. Given:

Altitude	15,000 ft.
Actual time of fall	35 sec.
Trail in mils.	70 mils
Ground Speed.	150 knots

2. Find:

Actual range Angle (in tan function) that would be correct for such data.

3. Solution:

Tan function of Actual Range angle equals Actual Range in feet divided by the Altitude in feet.

G.S. miles per hour = G.S. knots x 1.15
G.S. feet per sec. = G.S. miles per hrs. times 1.467
W.R. in ft. = G.S. in ft. per sec. times A.T.F.
Trail in ft. = $\frac{\text{Alt.}}{1000}$ x T in mils.
A.R. in ft. = W.R. in ft. - Trail in ft.

Thus:

150 knots x 1.15 = 172.5 MPH G.S.
172.5 x 1.467 = 253.06 ft/sec. G.S.
253.06 x 35 sec. = 8857.1 ft. W.R.
$\frac{15{,}000 \text{ (alt.)}}{1000}$ x 70 = 1050 ft. trail.
8857.1 − 1050 = 7807.1 ft. A.R.
$\frac{7807.1}{15000}$ = .5205 tan function A.R. angle

D. Same problem and mechanical Solution by Sight.
1. Given: Same as above.
2. Find: Position of rate quadrant (A.R. angle) in tan function.

3. Solution:

a. Set tape speed.

1) Determine tape speed (analogous to ground speed) in mils per second. To do this divide G.S. ft/sec. by the number of feet subtended by one mil at that altitude. At 15,000 ft. one mil subtends 15 ft.--and in one second 253.06 feet are covered (see above)--and there are 15 feet in each mil, so that tape speed mils/sec. equals 16.86 mils.

2) For a more accurate setting of the tape, multiply this amount by any number of seconds so long as the answer stays within the limits of the steel tape (1800 mils). Using a stop watch, require that number of mils for the chosen number of seconds to pass a given point.

b. Set Disc Speed into Sight. (divide bombing constant by A.T.F.). Also set trail in.

c. Set maximum sighting angle, turn on telescope motor, and synchronize on some mark on the tape. Synchronize until the transverse hair follows the mark from maximum to minimum.

d. Read the position of the rate quadrant. This can be done by referring to the scale opposite the rate quadrant, but this will give only a rough tan function reading. A more accurate method of ascertaining the tan function posi-

tion of the rate quadrant is to sight through the optics after positioning the telescope indicator opposite the rate indicator and read the number of mils on the tape at the point upon which the transverse hair lies. Then divide this number of mils by 1000, and the exact tan function position of the rate quadrant will be revealed.
(NOTE: If the transverse hair is out of relationship to the position of the tel. quadrant, then the exact position of the rate quadrant will not be revealed by the use of the more accurate method just cited. In case of any discrepancy between the mathematical and mechanical answers, this should be first checked for.)

e. Compare the position of the rate quadrant, as actually found to exist in terms of tan function in the bombsight, with the position of the rate quadrant as it should exist according to the mathematical computation above.

E. If the results are consistent but in error, for example a 5 mil plus error exists at all points the usual causes are:

(1) Roller not zeroed.
(2) Worn roller.
(3) Calibration of the transverse cross hair.

F. If the results are inconsistent, showing plus or minus errors erratically, sheaves should be checked for dirt in the grooves, and the cable inspected for kinks or enlarged diameters. Large errors in the direction of increasing dropping angles, should lead one to suspect that the disc is not correctly transmitting its rotation to the roller. If records are kept of the values found at each 50 hour inspection, incipient troubles may be discovered.

(1) Slipping roller.
(2) Erratic disc speed.

G. Repeat with different problems to give a wide range of dropping angles.

REFERENCE PUBLICATIONS

N.O.P. #649 - Operation of the M4. 5. 6 and 7 sights. Students should become acquainted with the material in this pamphlet.

N.O.P. #650 - Maintenance of the M4. 5. 6 and 7 sights. Additional points concerning maintenance will be found in this pamphlet.

N.O.P. #638 - Operation of the M3 sight.

N.O.P. #640 - Maintenance of the M3 sight.

Confidential letters of instruction should also be examined at this time, so that the student may become acquainted with information relating to changes and additional information not contained in N.O.P.s.

LOW ALTITUDE ATTACHMENT

See Field Maintenance And Calibration

A. Nomenclature.

1. Compass card.
2. Wind gear.
3. Adjustable scale (ballistic coefficient of the bomb).
4. Upper knob locks the compass card to the plate.
5. Lower knob locks the wind gear to the compass card.
6. Drift bar.
7. Scale on the right of the drift bar is ground speed.
8. Scale on the left of the drift bar is the adjustable scale.
9. Drift pointer is at the lower end of the drift bar.
10. Underbar is the true air speed scale.
11. The wind gear and the wind arrow are joined together.
12. Wind scale.

B. Given:

1. Drift on two headings.
2. Compass headings upon which drift readings were taken.
3. True air speed in miles per hour.

C. To Find:

1. The dropping angle.
2. Drift on any heading.
3. Ground speed on any heading.
4. Direction and velocity of the wind.

D. Assembly.

1. The instructor will bring out several of low altitude attachments and have the students attach them to the stabilizers, demonstrating the method for synchronizing the low altitude attachment before installation.

VAULT MATERIAL

The following material is available to the students and the instructors. This material is found in the vault, or in cabinets in the classroom.

1. Precession levels.
2. Clutch pullers.
3. .969 gauges.
4. Tachometers.
5. Interval timer clocks.
6. Combination voltmeters and continuity testers.
7. Jewelers' loupes.
8. Altitude computers.
9. Cardan (disassembly) wrenches.
10. Straight wrenches.
11. Large compass for blackboard drawing.
12. Aerial deadreckoning computers.
13. Large drawing of trail and rate mechanism.
14. Technical orders pamphlets and C.L.I.s.
15. Tripod mirrors, precession level stands, and other material for daily use will be found in the cabinets in the classroom.
16. Peep sights.
17. Three-legged tables and stem tables.
18. Wedges.
19. Stop watches.

I. REVIEW OF SIGHT NOMENCLATURE

The student should be sure that he understands the names, functions and/or adjustments for the following:

A. Rate End (outside).

1. Trail arm.
2. Trail plate.
3. Tachometer connection.
4. Altitude knob.
5. Turn knob.
6. Drift knob.
7. Search knob.
8. Displacement knob.
9. Rate knob.
10. Disc speed shift lever.
11. Telescope motor switch.

B. Rate End (Inside).
   1. Roller screw spindle.
   2. Roller carriage.
   3. Automatic release switch.
   4. Automatic release finger.
   5. Lower roller shaft (spline gear)
   6. Automatic release cam.
   7. Automatic release notch.
   8. Rate bevel gear.
   9. Rack, telescope.
   10. Search knob bevel gear.
   11. Telescope drive rack pinion.
   12. Telescope drive differential.
   13. Eccentric screw on #1 sheave.
   14. Cable operating sheave.
   15. Rate rack.
   16. Ground speed drum and scale.
   17. Rate quadrant.
   18. Telescope quadrant.
   19. Nut gear.
   20. Disc.
   21. Telescope rack.
   22. Telescope rack drive pinion.
   23. Telescope motor and governor points.
   24. Trail setting gear.
   25. Telescope clutch shaft.
   26. Rate bevel pinion.

C. Telescope cradle assembly.
   1. Telescope.
   2. Telescope return spring.
   3. Differential lever.
   4. Turret screw.
   5. Bell crank lever
   6. Gear sector.
   7. #5 sheave.
   8. Cross trail linkage.
   9. Cradle connecting rod.
   10. #6 sheave.
   11. Short cable (double).
   12. Cradle and gear sector pointers, index.

D. Balance of sight.
   1. Gyro caging knob.
   2. Gyro leveling knob.
   3. Turn worm and housing.
   4. Drift worm and housing.
   5. Drift index.
   6. Vertical gyro.
   7. Dovetail.

8. Eccentric cam and dovetail.
9. Cross trail mechanism or linkage.
10. Cradle differential lever.
11. Telescope light.
12. AES--if installed.

DEFECTS AND MALFUNCTIONS

A. Stabilizer brush.
   1. Moves back and forth across neutral sector.
   2. Moves off continuously in one direction (to upper or lower segments.)
      a. Dirt (bearings).
      b. Sector fouled or shorted.
      c. Broken lead to sector.
      d. slip ring brush corroded or bent.
      e. Unbalanced gyro.
      f. Dragging clutch.
      g. Slow, sluggish gyro.
      h. Slow servo motor.
   3. Adjustment - clean brushes with carbon tet. and check for grounds and shorts.
B. Failure of clutches to release.
   1. Corrosion.
   2. Dirt.
   3. Adjustment-keep clean and dry.
C. Sluggish gyros.
   1. Sticky brushes.
   2. Dirty commutator.
   3. Loose connections.
   4. Flexible lead with broken strands.
   5. Bad bearings.
   6. Adjustments - check and clean brushes, commutators and bearings.
D. Erratic disc speeds.
   1. Governor points pitted--or governor binding.
   2. Tachometer drive collar slips.
   3. Motor brush arm sticks on shaft.
   4. Adjustments - polish, tighten, clean and oil slightly.
E. Telescope Motor stops frequently.
   1. Defective toggle switch.
   2. Poor terminal connections.
   3. Cannon plug connections loose.
   4. Adjustments - adjust, clean and renew. Fit cannon plug and insure contact.
F. Stabilized brush won't move when drift knob is turned. Pilot cannot keep P.D.I. centered.
   1. Bombsight clutch not properly adjusted.
   2. Moisture or oil in the clutch.
   3. Friction collar slips.
   4. Brush binding on coil.

    5. Adjustments - adjust and clean. Increase clutch tension.

G. Bomb impact is consistently in error.

    1. Telescope is not properly aligned.
    2. Bombsight gyro precesses off because of improper balance.
    3. Dovetail not aligned.
    4. Stabilizer gyro unbalanced.
    5. Stabilizer not aligned.
    6. Release points not aligned.
    7. Quadrants not aligned.
    8. Bombsight cardan out of balance.
    9. Adjustments - send to shop for balancing if necessary and calibration.

DEFECTS AND MAL-FUNCTIONS (cont'd)

H. Difficulty in Synchronizing transverse cross hair on target.

    1. Transverse hair misaligned relative to position of telescope quadrant.
        a. Gyro precession excessive, caused by gyro not being properly balanced; excessive bearing drag; excessive pendulousness; excessive flex. lead drag.
        b. Failure to erect transverse hair properly.
            1) Gyro not in vertical when transverse hair was erected.
            2) Mirror not level when transverse hair was erected.
            3) Faulty technique.
        c. Failure to maintain gyro in vertical when bombing.
            1) Bubbles are off--need re-shimming.
            2) Faulty technique of bombardier.
        d. Dirt on sheave or kinked cable.
    2. Erratic disc speed.
        a. Is impossible to synchronize.
    3. Roller slippage.
        a. Is impossible to synchronize.
    4. Adjustments check gyro balance, vertical of optics, disc speed, roller slippage.

I. Difficulty in Synchronizing Fore and Aft Hair on Target.

    1. Stabilizer misaligned in plane.
    2. Reticle out of alignment.
    3. Rapid precession of gyro in transverse plane.
        a. Gyro not balanced properly.
        b. Bearings not functioning properly.
    4. AFCES not functioning properly about verti-axis in transverse plane.

5. Stabilizer gyro not revolving at proper speed to maintain stabilization.
6. Bombsight clutch slipping at too low a tension.
7. Servo (torque) unit not functioning properly.
   a. improper servo clutch tension.
   b. Oil on servo clutches.
   c. Isolated sector fouled, shorted or poor brush contact.
8. Adjustments check the following and make necessary adjustments: Alignment of stabilizer; reticle for alignment; balance of gyro; speed of gyro; clutch tensions.

J. Bombsight gyro not stable.
   1. Burned out rotor bearing.
   2. Heavy oil at high altitudes, or gyro not completely warmed.
   3. Soft carbon brushes reducing gyro speed.
   4. Adjustments check bearings; brush contact.

K. Course knobs turn too hard.
   1. Burrs on worm or gear.
   2. Tolerance between gears and worm not properly adjusted.
   3. Adjustments: Remove burrs: Adjust tolerances.

L. Large deflection errors.
   1. Sight stem lock nut not on properly. (M3)
   2. Sight stem locking plate loose or improperly positioned, i.e. dovetail misaligned.
   3. Sight stem locking pin not fitted into position, or has too much play.
   4. Adjustment: Check screws in sight stem locking plate for tightness check fit of sight stem pin.

M. Erratic bomb release.
   1. Auto-release contact dirty, burned or corroded, or release finger not properly adjusted.
   2. Adjustments-clean and service contact. Adjust release finger.

N. Isolated sector burning.
   1. Wires to isolated sector touching gyro case.
   2. Adjustments-check for ground on leads to isolated sector. This ground will energize one of the clapper magnet continuously.

O. Terminal plugs contacting case.
   1. Faulty installation or fitting.
   2. Adjustments-refit and reinstall.

SOME COMMON SIGHT ERRORS AND REASONS

A. Overshooting

1. Rate quadrant not positioned far enough downward, i.e. set at too small an AR angle.
    - a. Preset trail in the rate end.
    - b. Roller too small.
    - c. Disc speed set in too high.
    - d. Bombardier does not know how to synchronize rate.
2. Position of transverse hair out of relationship to position of telescope quadrant.
    - a. Can be caused by improper erection of transverse hair to vertical.
        - 1) Bottom of gyro tilted to front when transverse hair was erected.
        - 2) Rear of precision mirror was high when transverse hair was erected.
        - 3) Faulty technique in calibrating.
    - b. Bottom of gyro tilts to rear when bombing.
        - 1) Fore and aft bubble is high to front.
        - 2) Incorrect rate of precession causing bottom of gyro to move to rear rapidly.
    - c. Dirt on one of the sheaves-or a kinked cable.
    - d. Auto-release closing too late.
    - e. Loose terminals leading to auto-release points.
3. Bombardier lacks knowledge of synchronization, and sets in too little rate.
    - a. This reduces the speed of drive of the telescope quadrant. Rate quadrant positioned at too small an actual range angle quadrant. Both of these conditions work together to cause a late release.
    - b. Too much trail set in.

B. Undershooting.

1. Rate quadrant positioned too far downward, i.e. set at too large an AR angle.
    - a. Disc speed set in too low.
    - b. Subset trail in the rate end.
    - c. Roller slips on disc.
2. Position of transverse hair is out of relationship to position of telescope quadrant, i.e. latter (at all or some points in its range) is at smaller angle than corresponding sighting angle. For example, if the optics are open to a sighting angle of 40°, the telescope quadrant indicator will not read 40°.

a. Can be caused by improper erection of transverse hair to vertical.

1) Bottom of gyro tilted to rear when transverse hair was erected.

2) Front of precision mirror was high when transverse hair was erected.

3) Faulty technique in calibrating.

b. Bottom of gyro tilts to front when bombing.

1) Fore and aft bubble is high to rear.

2) Faulty technique of bombardier.

3) Abnormal rate of precession causing bottom of gyro to move to front rapidly.

c. Dirt (piece of dirt) on one of sheaves which bears on cable when transverse hair being erected but does not bear on cable when optics are positioned at AR angle or wider.

3. Bombardier lacks knowledge of synchronization and sets in too much rate.

C. Left deflection errors.

1. Dovetail misaligned counter clockwise.

2. Transverse bubble high to the left with gyro in true vertical.

3. Improper erection of fore and aft hair to vertical.

a. Bottom of gyro was tilted to left when fore and aft hair was erected.

b. Right side of precision mirror high when fore and aft hair being erected to vertical.

4. Stabilizer misaligned counter clockwise.

5. Gyro not properly balanced causing a rapid rate of precession of bottom of gyro toward right.

6. Fore and aft balancing weights loose and creeping to the rear.

7. Cross trail clamp lever turret head screw loose; top of telescope creeping left.

D. Right deflection errors.

1. Dovetail misaligned clockwise.

2. Transverse bubble high to the right with gyro in true vertical.

3. Improper erection of fore and aft hair to vertical.

a. Bottom of gyro was tilted to right when fore and aft hair was erected.

b. Left side of precision mirror high when fore and aft hair being erected to vertical.

    4. Stabilizer misaligned clockwise.
    5. Gyro not properly balanced causing a rapid rate of precession of bottom of gyro toward left.

E. Constant upwind or constant downwind errors.
    1. Former caused by pre-set trail in the C.T. mechanism-or by too much trail set in C.T. mechanism.
    2. Latter caused by sub-set trail in the C.T. mechanism-or by too little trail set in C.T. mechanism.

POINTS TO BE REMEMBERED

A. NEVER OIL BEARINGS EXCESSIVELY. FOLLOW INSTRUCTIONS.

B. DO NOT OIL GUDGEON BEARINGS UNLESS THEY ARE CLEANED.

C. USE NO ABRASIVE ON A CLUTCH.

D. ALL INSPECTIONS WILL BE PERFORMED WHEN DUE.

E. ISOLATE ALL ELECTRICAL DIFFICULTIES WITH A CONTINUITY TESTER.

F. USE A FILE VERY LIGHTLY TO REMOVE BURRS FROM GEAR TEETH WHEN NOTHING ELSE IS AVAILABLE.

G. WHEN SIGHT IS MOUNTED ON THE STABILIZER, ROTATE SIGHT (USING COURSE KNOBS) FROM 0° DRIFT TO MAXIMUM DRIFT RIGHT AND LEFT TO INSURE EVEN WEAR OF THE STABILIZED SECTOR.

H. ALL GYROS MUST BE STOPPED TO CLEAN THE COMMUTATORS.

CHECK FOR ELECTRICAL SHORT CIRCUITS

A. Sight.
    1. Disconnect motor supply leads at gyro housing terminal block.
    2. Remove terminal clip on level clamp.
    3. With continuity tester, check between the gyro housing and the lead of the circuit being tested.

B. Stabilizer.
    1. Insert insulating material under the slip ring brushes.
    2. With a continuity tester, check between the cardan flexible lead terminal block and the gyro housing. Move the gyro so the stabilizer brush will complete all circuits.

C. Servo.
    1. Insert insulating material under the slip ring brushes.
    2. Disconnect the field lead at the grounded brush of the servo motor. Unscrew brush holder plug and remove the brush.
    3. Turn servo switch off.

4. heck between the gyro housing and the servo brush.

ATTENTION:

In checking any circuit for grounds it is necessary to remove all ground terminals which are part of the one wire system, AND CHECK FOR FAULTY WIRING AND CONNECTIONS.

BEARINGS

A gudgeon bearing is a short shaft bearing. A locked gudgeon bearing is locked by means of a flange and a spacer in order to control the direction of expansion. Expansion, therefore, takes place in a direction away from the locked bearing.

The sight gyro and cardan, when cold, are unbalanced with 1/1000th of their mass to the rear and right respectively. When the gyro warms up the expansion is away from the locked bearings, the mass is again evenly distributed.

The following sight bearings are locked: rear gyro gudgeon bearing and right cardan bearing. The right cardan bearing is locked to prevent changing cable tension.

The following bearings on the stabilizer gyro are locked: gyro rotor bearing on the end opposite the commutator end and the gyro gudgeon bearing on the isolated sector side.

When the stabilizer gyro is cold and dead, the contact brush should ride upon the upper six volt segment of the isolated sector. When hot, the center of mass of the gyro moves toward the commutator end and the brush should now be on the neutral segment, providing that the stabilizer housing is level. The gyro gudgeon bearing next to the isolated sector is locked so that expansion will not change the seating or tension of the brush on the isolated sector.

STANDARD CLEARANCES AND NOTES

A. Replace carbon brushes when one quarter inch is worn off compared with a new brush.

B. Replace telescope motor brushes when one is worn more than the other, or they do not meet commutator at 90° angle.

C. Telescope motor brushes must be in line.

D. Never cut pigtails. Fold back one-half inch of end of pigtail and refold that in half. Pigtails are cut to exact length at the factory.

E. Use no solder on connections.

F. Motor brushes should make 85% contact.

G. Brush plugs on the bombsight extend one quarter inch. Brush plugs on stabilizer extend 5/16".

H. Telescope governor should fall when 15° out of the vertical, with tension relieved.
I. Telescope points arc across top at low speed. Farther down, at high speed.
J. Telescope points make 30% contact.
K. Altitude knob disc speed low--101 (plus or minus 1/2) to 246 (plus or minus 1/2). High: 246 to 593.
L. Slip ring brushes should make 100% contact.
M. Running temperature of sight gyro is 140°F.
N. Run sight gyro 10 minutes after oiling; then clean commutator, brushes and brush tubes.
O. Flexible leads should be "S" shaped from cardan to gyro when 3 flexible leads are used; and heart shaped when 2 are used.
P. Never run roller on center of disc unnecessarily.
Q. Never use abrasives on roller.

R. Do not use compressed air on bearings.
S. Use crocus cloth parallel to sectors to clean isolated sector.
T. No continuity between sector of isolated sector.
U. Isolated sector brush must make 100% contact.
V. A pendulous gyro has its axis of suspension above its center of gravity.
W. Too much pendulousness causes wear on parts and undesirable turns.
X. P.D.I. brush should move 5 1/2° in each direction.
Y. P.D.I. brush clearance is .008".
Z. Slippage of bombsight clutch is 18 to 24 pounds.
Aa. Slippage of auto pilot clutch is 10 to 12 pounds.
Ab. Slippage of drift clutch is 6 to 8 pounds.
Ac. Slippage of servo clutch is 32 pounds. (min.)
Ad. Drift pointer clearance is .012".
Ae. Vertical clearance of sight stem with pin in is .003" to .007".
Af. End play of turn knob is .003" to .004".
Ag. Pigtails must not ground on case.
Ah. Nut gear clearance is two teeth or .006" or 10 mils.

SUBSTITUTES FOR THE PRESCRIBED EQUIPMENT USED IN CALIBRATION AND MAINTENANCE

1. When a hypodermic needle is not available for oiling, a piece of small wire may be used. A drop of oil will run down the wire very easily or may be picked up on the end.

2. In the absence of a continuity tester a test light may be rigged up to check continuity. Of course no resistance reading can be obtained, but the improvised instrument is an accurate check for shorts and grounds. The light may be made from any available material, even a flashlight.

BOMBSIGHT COVER TYPE A-1

A. Instruction for 12/24 volt Changeover.

1. When shipped from the factory, covers will be connected for 24 volt use.

2. To change from 24 volt wiring to 12 volt wiring:

a. Holding the terminal block so that the connector cord is down, remove cover of terminal block with Phillips Head screw driver.

b. Loosen the screw at the top of the top bus bar on the left hand side, and disconnect the heater wire.

c. Secure this wire to the unused terminal of the top bus bar on the right hand side. Draw screw down firmly.

d. Similarly, disconnect wire from the bottom screw of the top bus bar on the left hand side, and secure it to the top terminal of the bus bar directly below.

e. CAUTION: If bus bars are separated by fibre separators, be sure separators are replaced to avoid short circuit.

f. Never roll or fold this cover.

g. Replace cover.

h. Prominently mark cover, or attachment plug, "12 Volts".

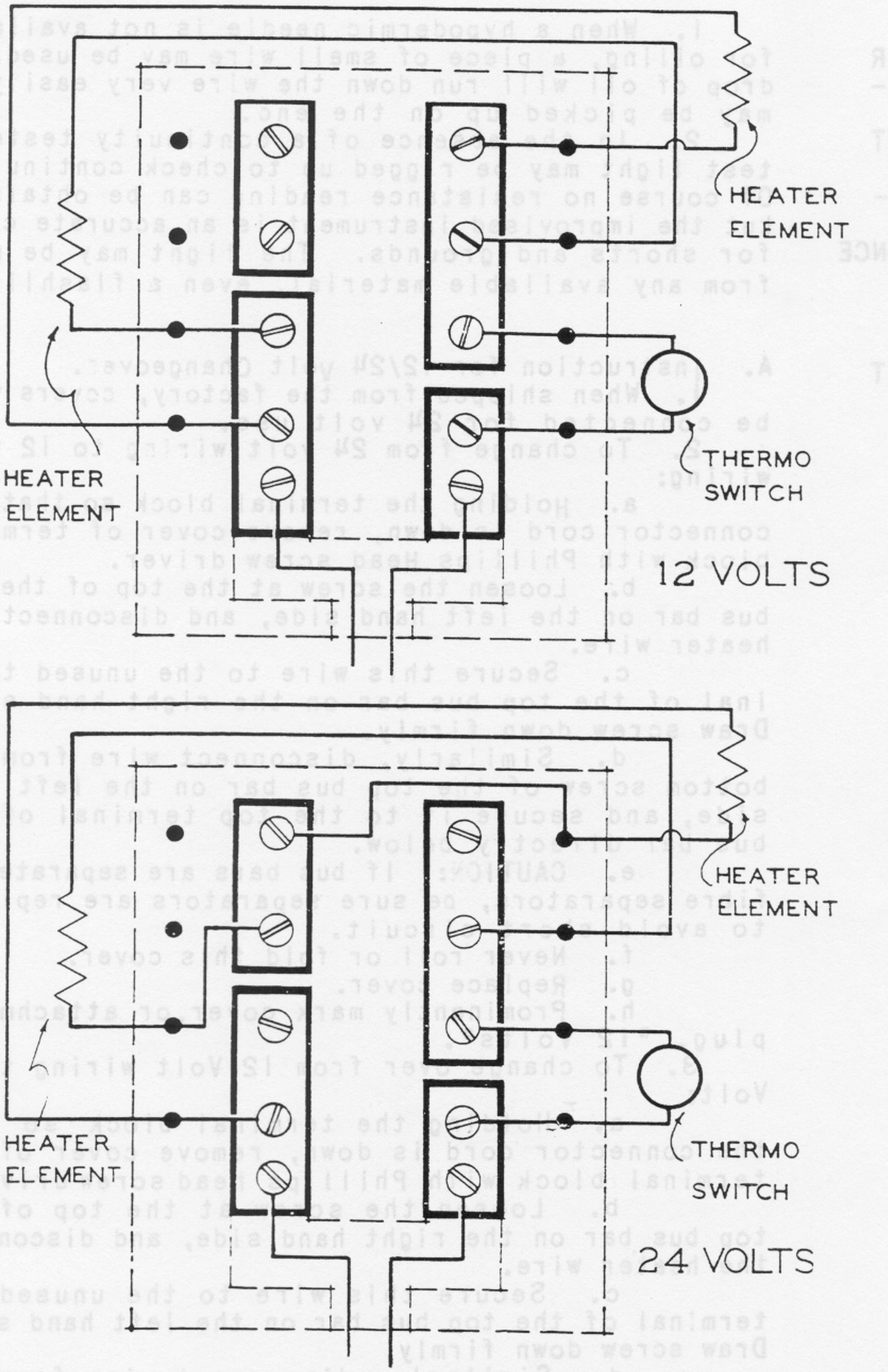
3. To change over from 12 Volt wiring to 24 Volt:

a. Holding the terminal block so that the connector cord is down, remove cover of the terminal block with Phillips head screw driver.

b. Loosen the screw at the top of the top bus bar on the right hand side, and disconnect the heater wire.

c. Secure this wire to the unused top terminal of the top bus bar on the left hand side. Draw screw down firmly.

d. Similarly, disconnect wire from the



BOMBSIGHT COVER (TYPE A-1)

FIG. 69

bottom screw of the top bus bar on the left hand side, and secure it to the top terminal of the bus bar directly below.

4. Cautions.

a. If bus bars are separated by fibre separators, be sure separators are replaced to avoid short circuit.

b. Never roll or fold this cover.

c. Replace cover.

d. Prominately mark cover, or attachment Plug, "24 Volts."

Acceptance of Sight, Stabilizer and Calibration Units.

It is sometimes necessary for a maintenance man to assume responsibility for the acceptance of units in the field. In accepting sight units or other BSM equipment, a set procedure is followed, and this part of the supplement might be called an inventory check of Acceptance. It is seldom that a maintenance man is called upon to assume this responsibility, but since it is true in isolated cases we present this material for his benefit.

C.L.I. C-42-3

a. Inventory List of Bombsight Assembly Consists Of:

- 1 Bombsight
- 1 Directional Stabilizer
- 1 Bombsight cover.
- 1 Log book and cover(sometimes sent separate).
- 1 L.A. Device and bracket.
- 2 Precession Charts (in log books).
- 1 Kit of Scales (12)
- 1 Hand held disk speed tachometer No.
- 1 Envelope containing release lever locking arrangement.
- 1 envelope containing B.S. coupling collar, locking pin and shims(when Bombsight unit only is sent.)

b. The Inventory List Of The Bombsight Calibration Outfit Should Consist of The Following:

- 1 Pedestal, three point adjustment, including:
  - instrument Panel
  - Adapter for M-4 sight.
  - Revolving head
  - Pilot director indicator
  - Ammeter
  - Voltmeter
- 1 Beam Target Tape, including:

Variable speed tape motor
Take up, target tape
Steel tape and Silk tape.
Bracket, target beam attachment
Bracket, target beam with level.
4 plates, precession grid
1 plate, cross trail MK XV-3
2 Dust caps 1 cable adapter for M-3
1 clamp, directional connecting rod.
4 screws for mounting stabilizer.
1 plumb bob. 1 Cord connector (3 pole)
1 Table, precesion bombsight, stem bushing
1 Table, precision 3 leg. (Mod. -3)
1 Table, precision 3 leg. (Mod. -4)
3 Peep sigts 1 Master precision level
1 Mirror, true optical
1 Platform, observers
1 Chart, tangent with cover
1 Tachometer, disc speed
1 Stop Watch

COMPARISON CHART

NUMBER SIGHT	HAS AES	VOLTAGE		MAXIMUM SIGHTING ANGLE	
		12v	24v	77°	90°
M-4	No	Yes	No	Yes	No
M-5	No	No	Yes	Yes	No
M-6	Yes	Yes	No	Yes	No
M-6M	Yes	Yes	No	No	Yes
M-7	Yes	No	Yes	No	Yes
M-9	No	No	Yes	No	Yes

BALL BEARING CHART

FOR M3 TO M9 SIGHTS AND STABILIZERS

MFGR. NO.	WHERE USED
465837	Telescope Armature Commutator End.
465836	" " Governor " .
NORMA 4666	Tachometer Shaft
NORMA 4666	Governor Shaft Outer End.
NORMA 4666	Low Altitude Spring Adapter.
465681	Governor Shaft Inner End.
465839	Speed Roller
465681	Telescope Cradle Drum, Both Sides.
465681	Telescope Cradle Gudgeon, Both Sides.
465682	B.S. Cardan Tilting, Locked end.
465369	B.S. Cardan Tilting, Free end.
465682	B.S. Gyro Tilting, Free end.
465661	B.S. Gyro Tilting, Locked End.
465564	B.S. Rotor Armature, Upper end.
465663	B.S. Rotor Armature, Lower end.
465662	Stabilizer Rotor Armature, Both Ends.
465834	Stabilizer Gyro Tilting, Locked End.
465835	Stabilizer Gyro Tilting, Free End.
1200C-005	Stabilizer Cardan Gudgeon, Lower End.
1203C-005	Stabilizer Cardan Gudgeon, Upper End.
465837	Servo Armature, Both ends.
465837	Servo Intermediate Pinion, Both Sides.
465833	Servo Cardan Drive, Both Sides.
465838	Servo Clutch Gears, Both Sides.
466042	Precession Motor, Armature, Pinion end
	Precession Motor, Armature, Commutor end.